Review for Midterm 1

Agenda

- Finish object recognition
- Review for Midterm 1

Announcements

- Turn in your short papers on titanium
- Green scantron

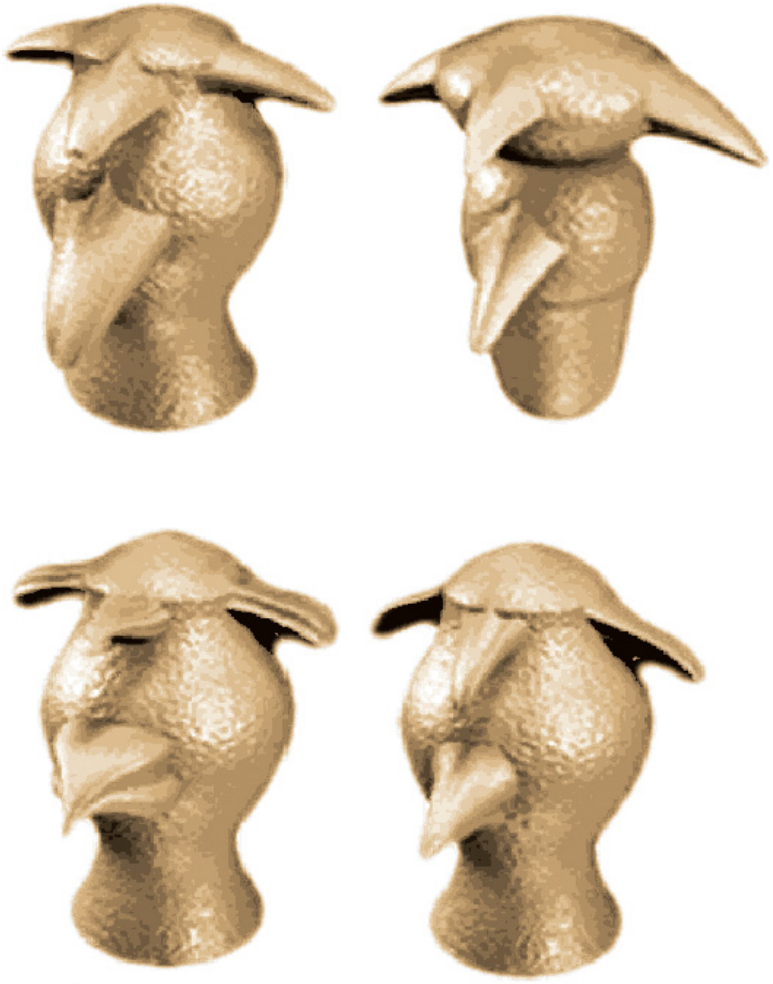
Are faces special?

1. Prosopagnosiacs fail to recognize people but can recognize other things.
   - Suggests faces may be special
2. Functional independence: double dissociation between object and face rec.
3. Anatomical separation: fusiform face area
   - May also be an expertise area
4. Are faces and objects processed differently?
   - Holistic versus analysing parts

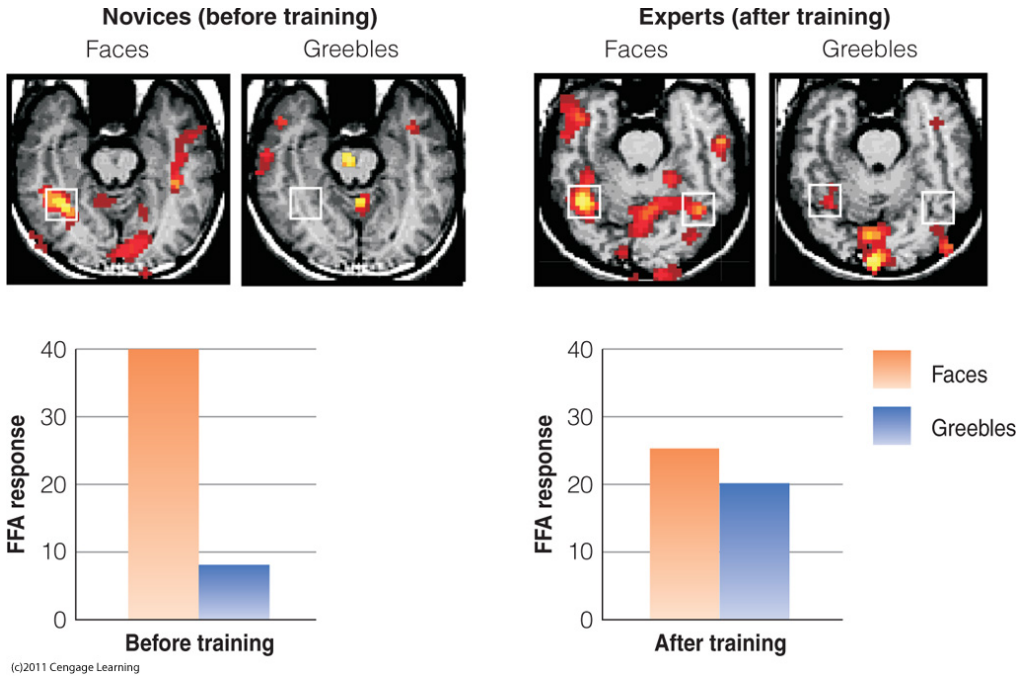
Is face recognition just specialized object recognition?

- Expertise
  - Are faces our most expert domain of recognition?
  - Similar to perceptual filling in of vertical bars
    - Experts at perceiving vertical lines

Expertise, yes!



Greeble stimuli used by Gauthier. Participants were trained to name each different Greeble.



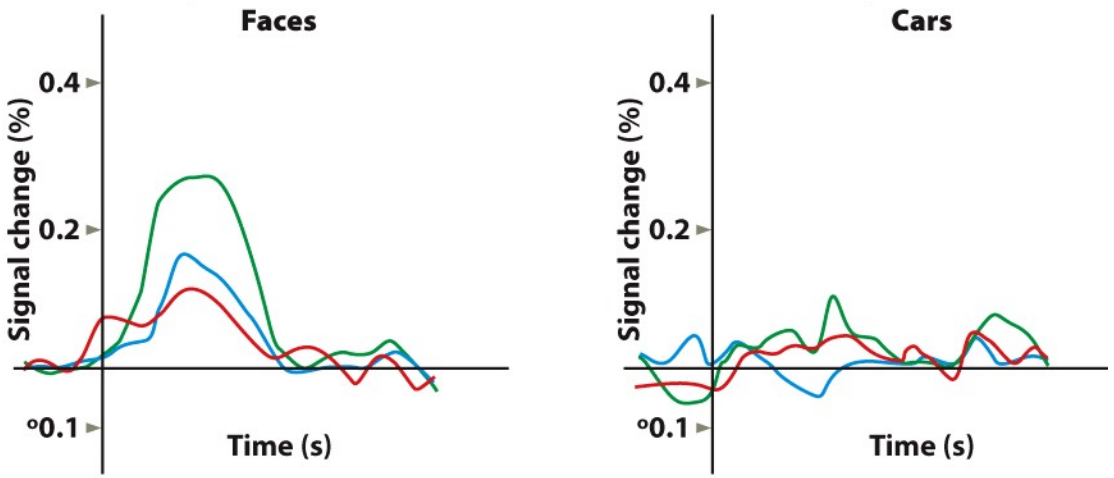
Magnitude of brain responses to faces and Greebles (a) before and (b) after Greeble training. The colored areas in the brain records indicate brain activity. The FFA is located within the white squares.

Training modulates FFA activities

Expertise, NO!

FFA activity is related to stimulus class and not expertise

Identify the specific car/face
Identify the category (car or face)
Wrong response



A group of car aficionados viewed pictures of faces an

Schedule for Today

- Review
  - Methods
- Questions

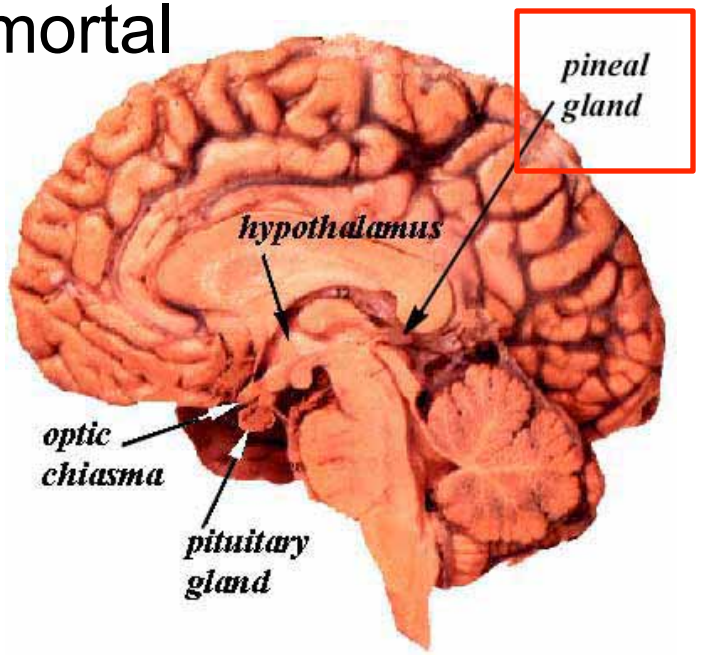
Black Box = 

Cognitive Neuroscience

- Infer what is happening by looking at behavior
  - Behavioral paradigms
- Observe what happens when the box (the brain) is damaged
  - Case studies
- Observe what happens when we mess with the box
  - Brain stimulation
- Can image what is happening inside the box
  - Brain imaging

History: How is mind related to the brain?

- Mind-body problem: how can a physical substance give rise to our feelings, thoughts, emotions?
- Dualism - Rene Descartes (1596-1650)
  - Mind was non-physical (awareness) and immortal
  - Brain was physical and mortal
  - Interact in the…



How is mind related to the brain?

- Dual-aspect theory (Spinoza)
  - Mind and brain are two aspects of the same thing (emergent properties)
  - Subjective and objective

Subjective

Objective

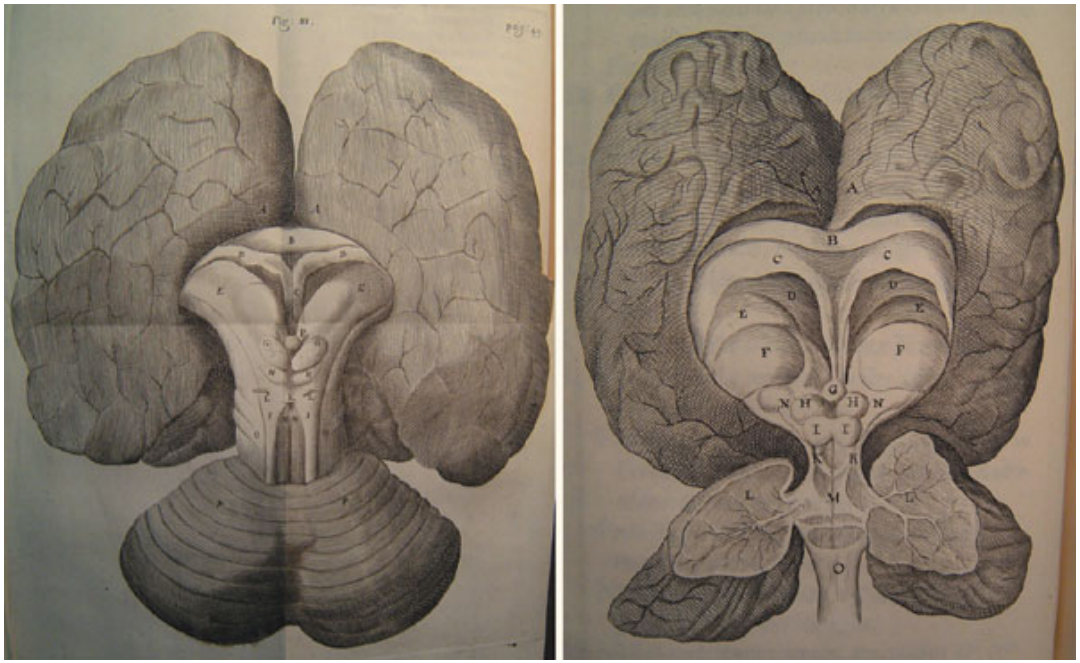
How is mind related to the brain?

- Dual-aspect theory (Spinoza)
  - Mind and brain are two aspects of the same thing (emergent properties)
  - Subjective and objective

- Reductionism (Churchland, Crick)
  - Mind can be reduced to biological constructs (e.g., patterns of neuronal firing, neurotransmitters)
  - “there is no soul, no mind, only the brain”
  - Only objective

How the mind got into the brain

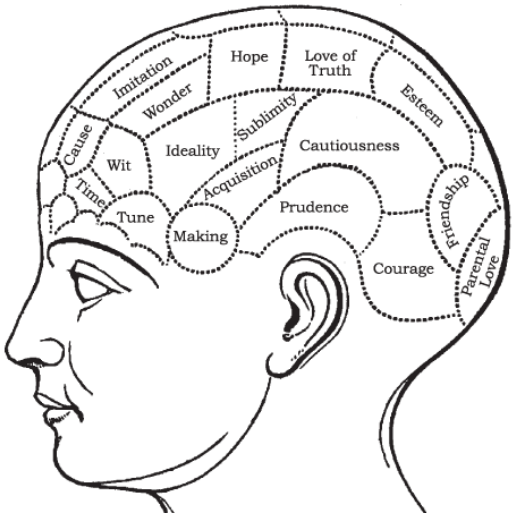
- Thomas Willis (17th century)
  - Father of clinical neurology. Linked brain damage with cognitive dysfunction by following patients for many years and then doing postmortum dissections.



The illustration shows a normal brain (left) and a brain from a case of congenital mental retardation(right).

Phrenology (early 19th century)

- Led by Franz Gall (1758-1828)
- "Localizationist" view
  - *Cognitive* functions to specific brain regions
  - Idea:
    - Using a mental function caused corresponding brain region to grow bigger,
    - Which created bumps on skull



The good…

Brought about the idea that different mental functions are localized to discrete brain regions

the bad…

Cannot determine cognition by bumps on the skull (if only it were that easy)

and the ugly

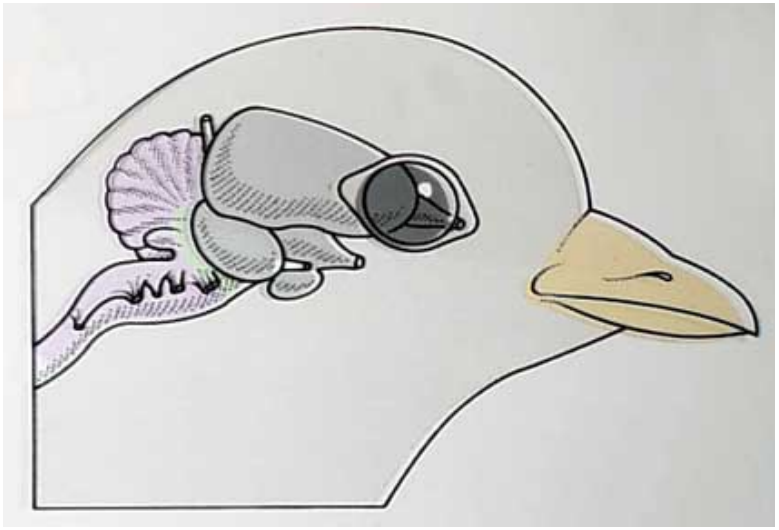
Good mother

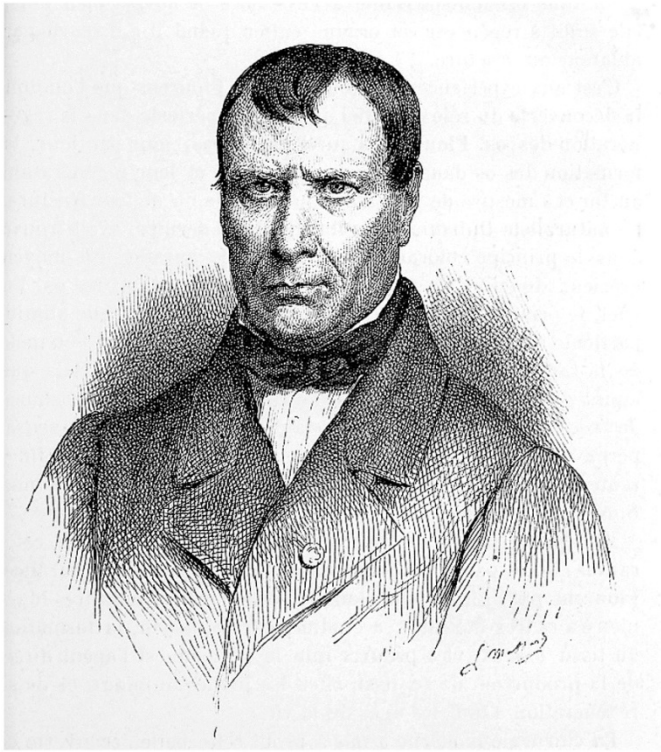
Bad mother

Or who we should marry

Localizationism vs Holism

- Aggregate field theory – holism
  - *Whole brain participates in each behavior.*
    - Birds with brain lesions recover no matter where lesion was
    - Lesions did not produce specific deficits.

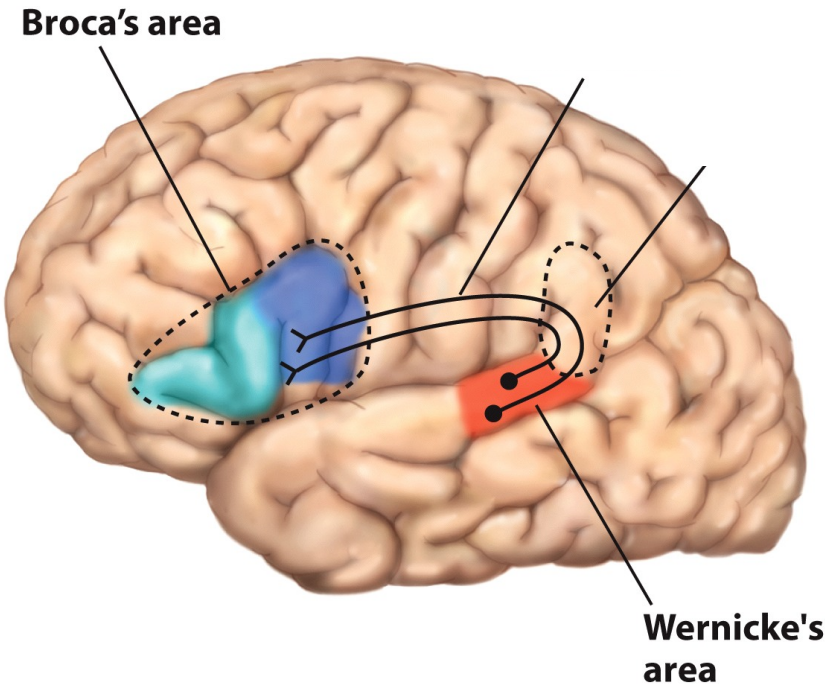




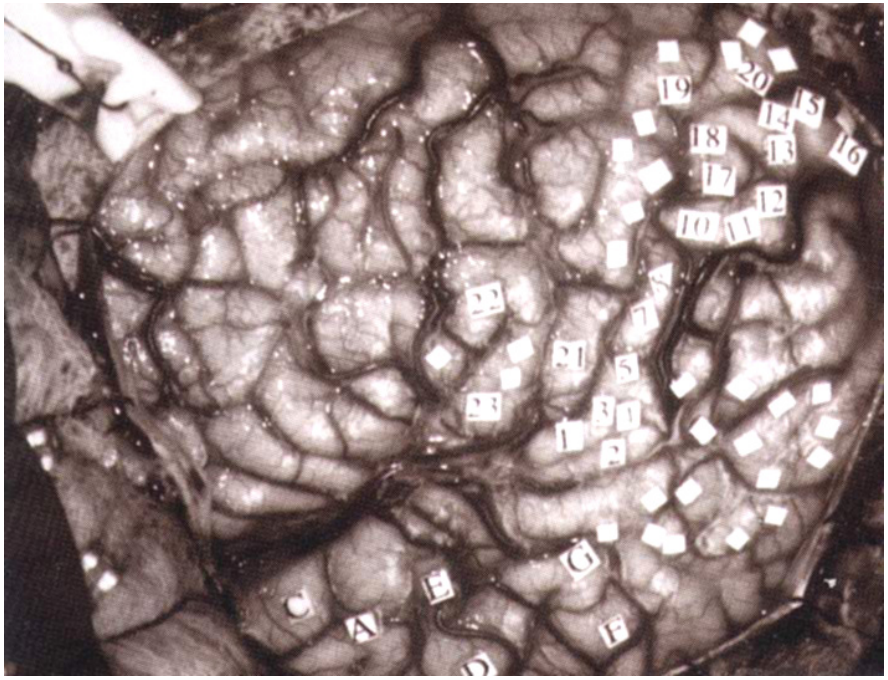
Pierre Flourens

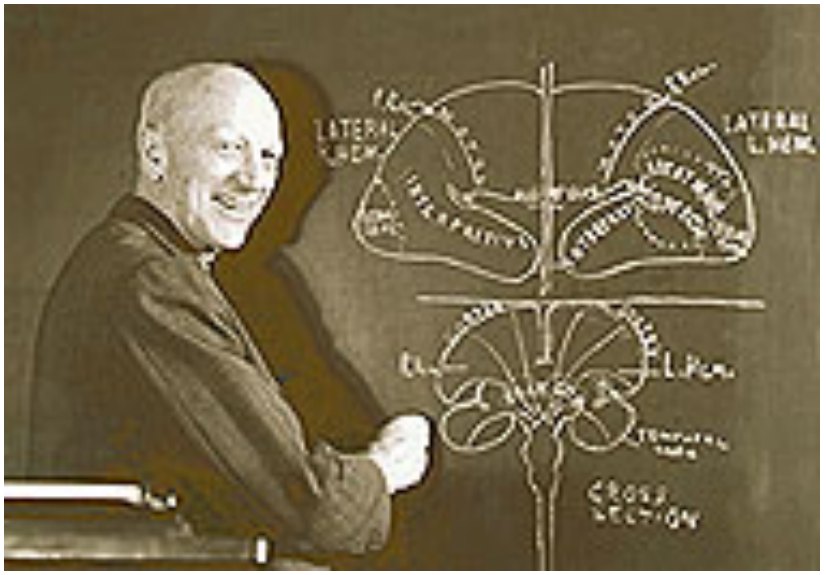
Localizationism (1860s)

- 1861: Paul Broca's patient "Tan"
  - Inability to generate speech *(Broca's aphasia)*
  - Post-mortem autopsy found left anterior region lesion
- 1874: Carl Wernicke
  - Comprehension loss *(Wernicke's aphasia)*
  - Post-mortem autopsy found left posterior region lesion



Wilder Penfield
Canadian neurosurgeon
(1896-1976)





- 1950s: *stimulated* brain tissue to find source of epileptic seizures

- stimulating different parts of brain elicited different movements, sensations, memories, etc.

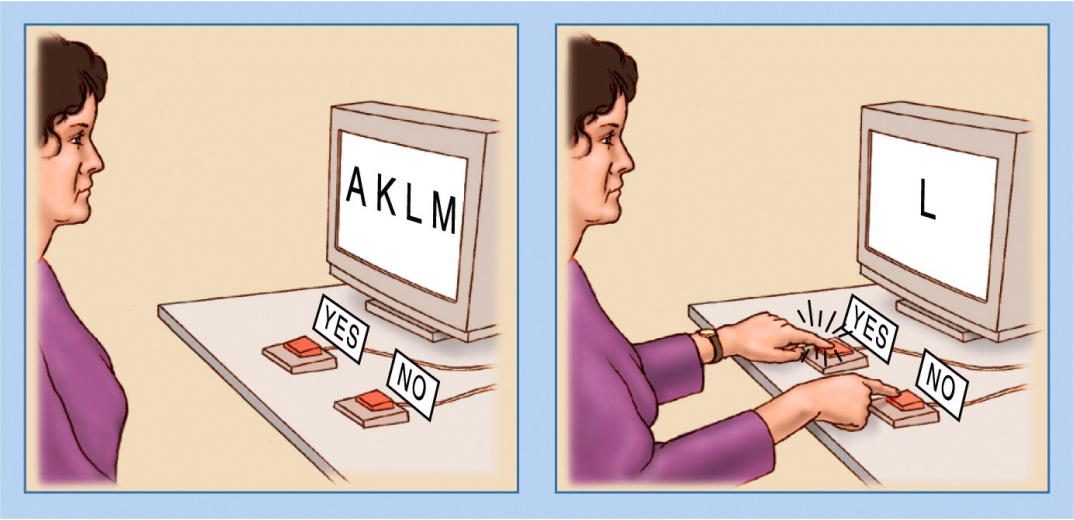
- developed map of motor cortex "motor homunculus"

Localizationism vs Holism: Who wins?

- Both were partially right 

- Specific processes can be localized to single brain regions
- BUT complex functions are carried out by many brains regions acting in concert
- Debate continues in almost every domain of study in cognitive neuroscience.

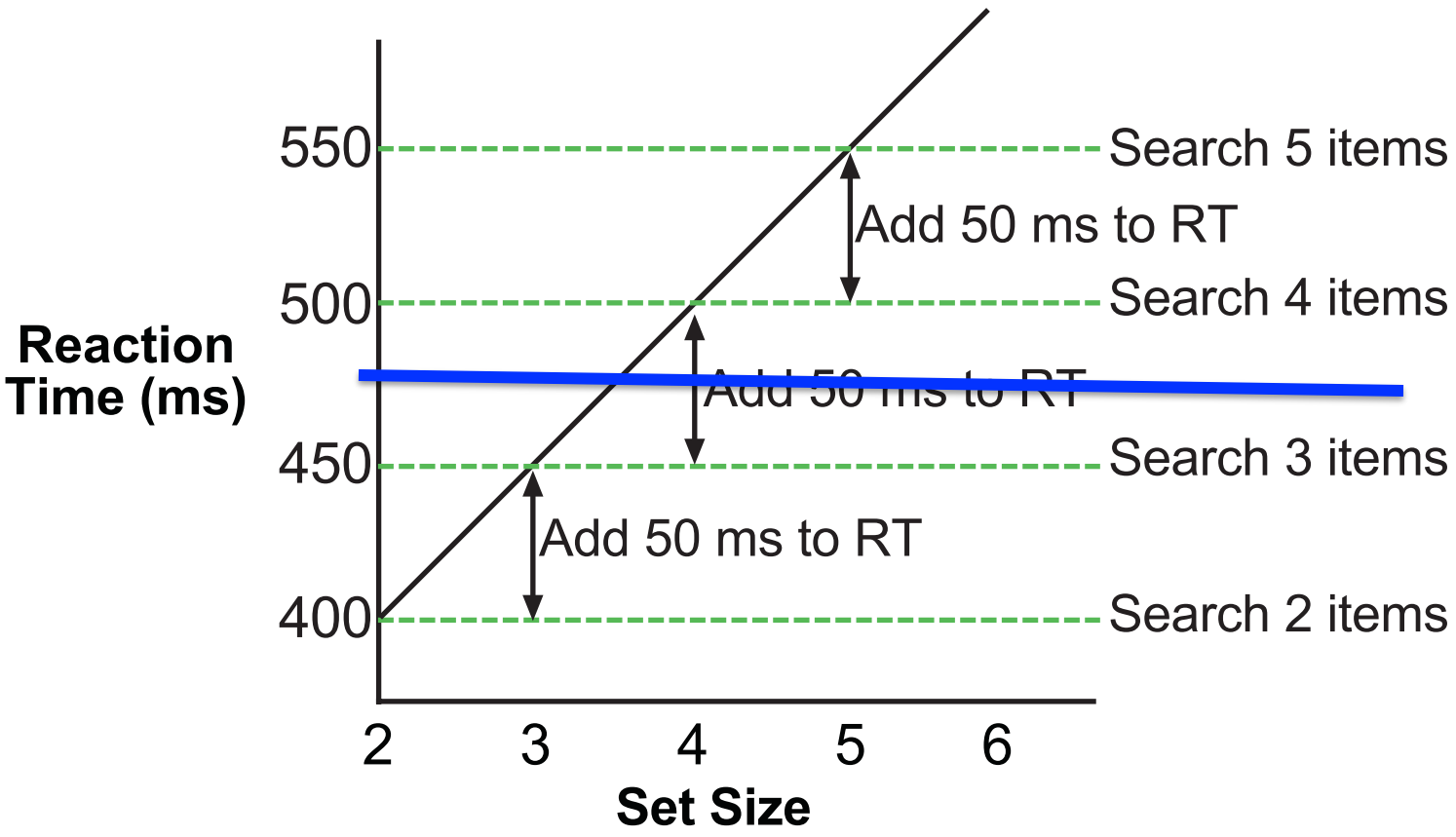
Behavioral paradigm example: Sternberg short-term memory experiment



- Subject sees letters on the screen and then has to decide if a letter came from the group.
-
-

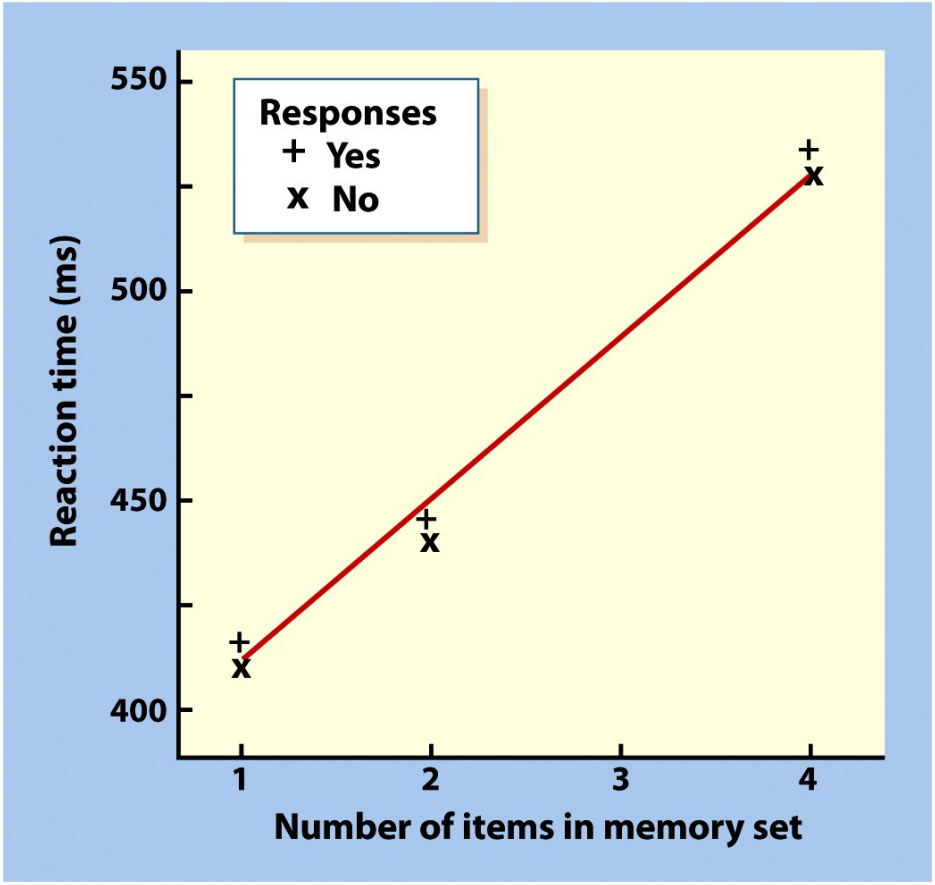
Serial search: linear increase in RT

RT goes up by 50 ms for each item added to the array (Slope = 50 ms/item).



Parallel search: flat RT function

Reaction time increases as a function of learning set!



- Search time is a linear function of the number of items in the memory set
- Search time is the same regardless of whether the probe item was part of the original list (yes/no responses), suggesting an **exhaustive** search.

Conclusions: memory items are scanned serially during memory search

Methods

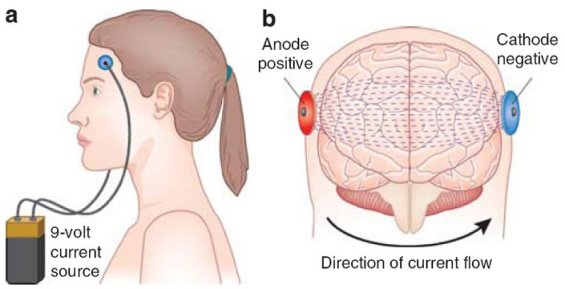
- Invasive – damage to scalp or brain
  - Deep brain stimulation
  - Single cell recording & brain lesions
- Non-invasive – no damage
  - tDCS and TMS
  - EEG and fMRI

Methods

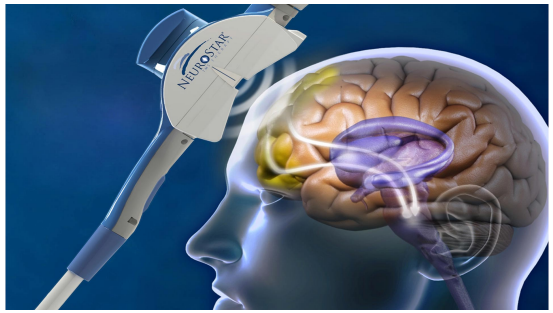
- Direct – actually stimulating/measuring neuron activity
  - Deep brain stimulation
  - Single cell recording
- Indirect – stimulating/measuring brain activity at a larger scale
  - tDCS, TMS
  - fMRI, EEG

Which method is best?

- I want to know the *causal* relationship between occipital lobe and vision
  - Brain stimulation (tDCS, TMS)
- I want to manipulate a deep brain structure non-invasively.
  - tDCS

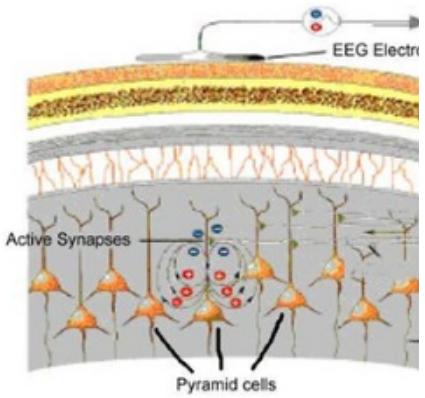


- I want to manipulate a shallow brain structure non-invasively.
  - TMS



Imaging – correlation only

- *When* does a brain function occur?
  - EEG (high temporal resolution)



- *Where* in the brain is used for this function?
  - fMRI (high spatial resolution),

Lesions, brain stimulation, brain imaging of a brain area

	Brain area A Lesion	Brain area B Lesion	
Function C	X	✓	Single dissociatio
Function D	✓	X	Single dissociatio

Together – double dissociation

Lesions, brain stimulation, brain imaging of a brain area

	Brain area A Lesion	Brain area B Lesion	
Function C	X	✓	Single dissociatio
Function D	X	✓	Single dissociatio

Together – two single dissociations
NOT a double dissociation

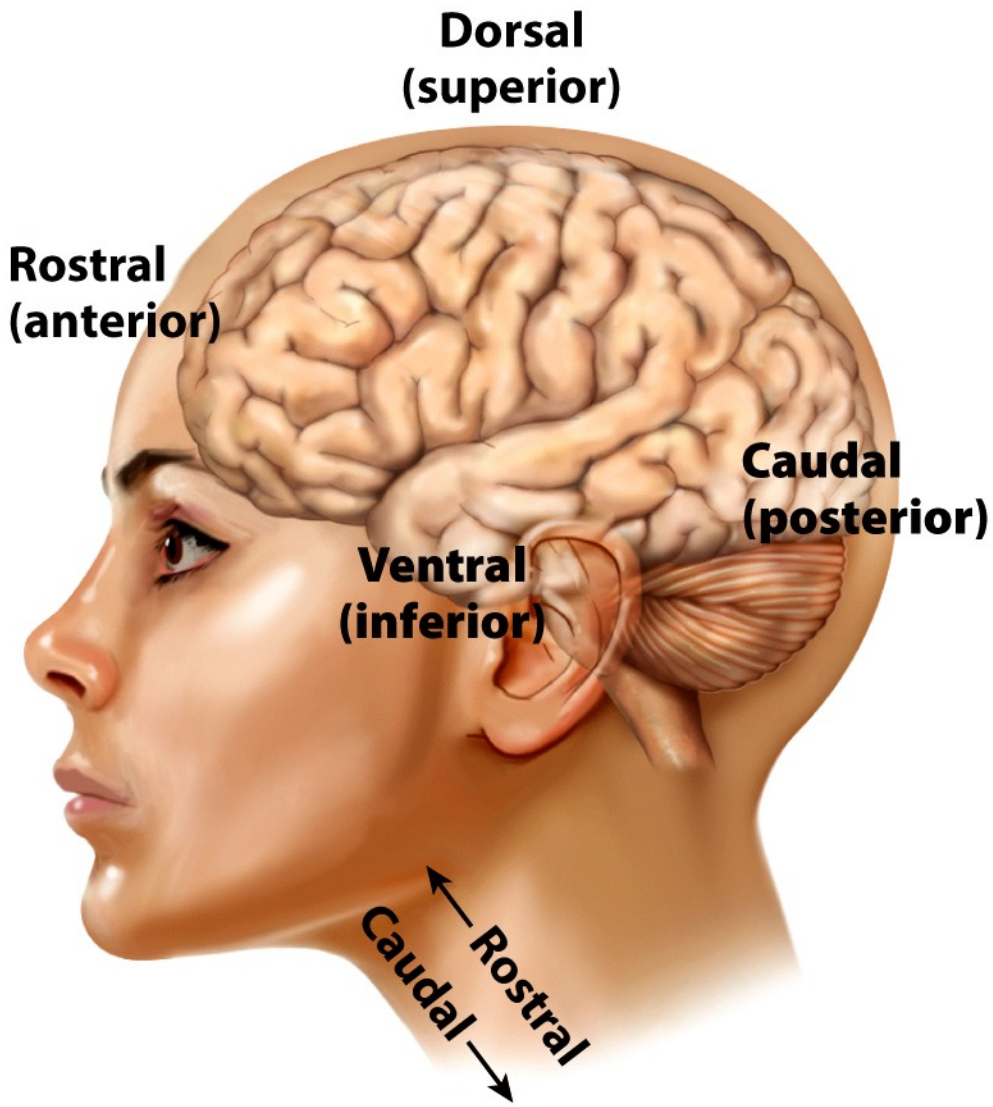
Lesions, brain stimulation, brain imaging of a brain area

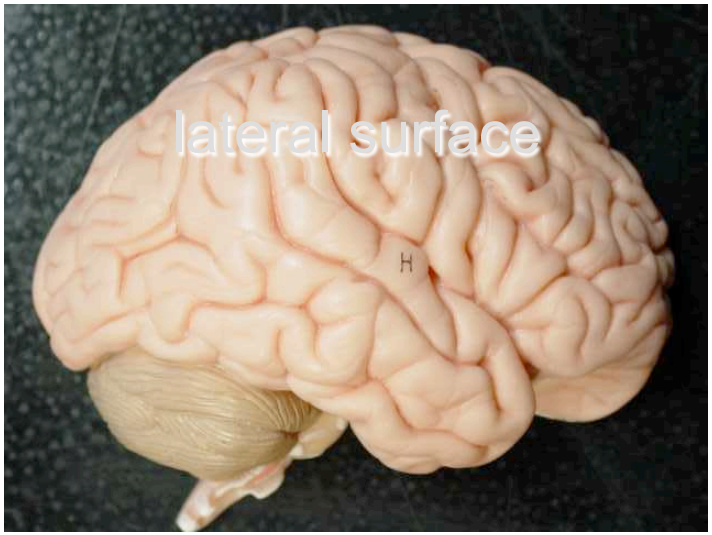
	Broca's area	Wernicke's area
Speech Production	X	✓
Speech Comprehension	✓	X

Single dissociatio

Single dissociatio

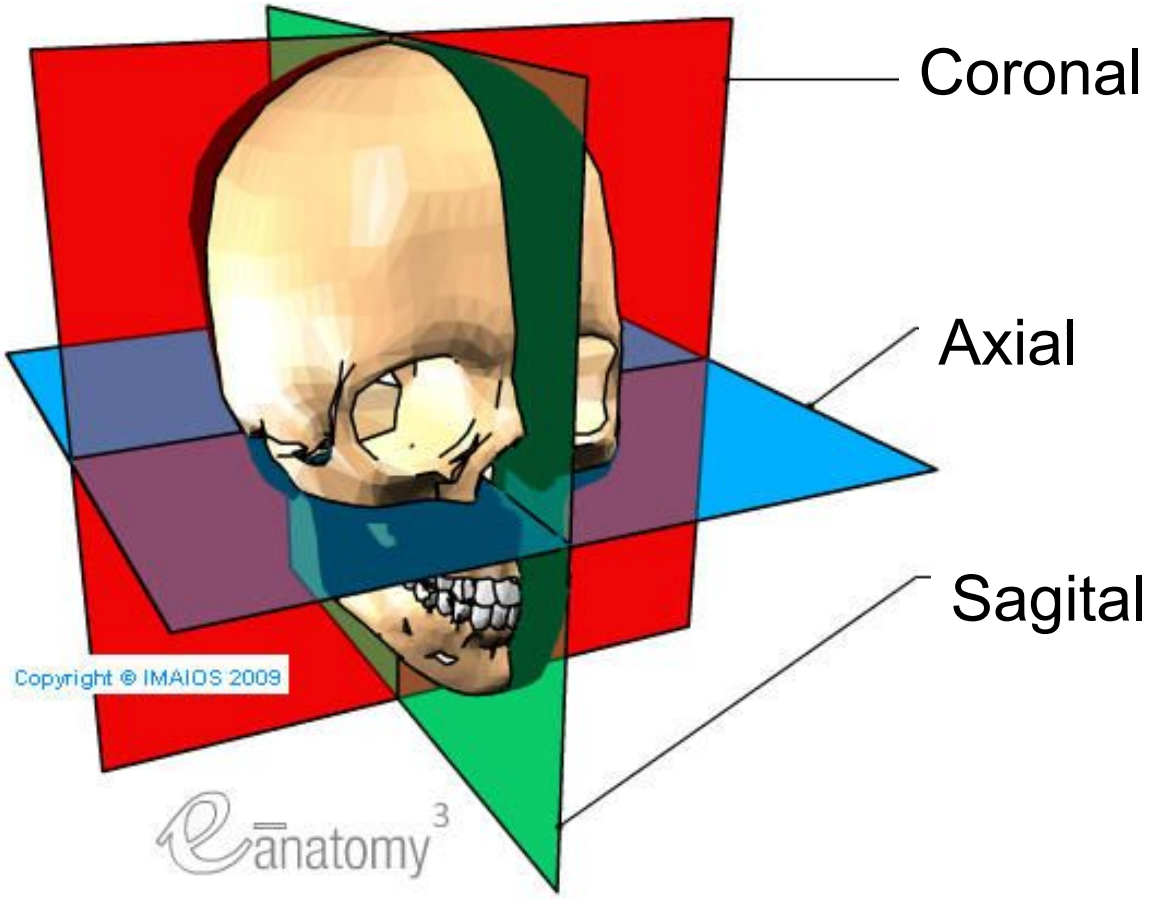
Together – double dissociation


Dorsal
(superior)
Rostral
(anterior)
Caudal
(posterior)
Ventral
(inferior)
Rostral
Caudal



- Lateral: toward the outside.

- Medial: toward the inside (middle).



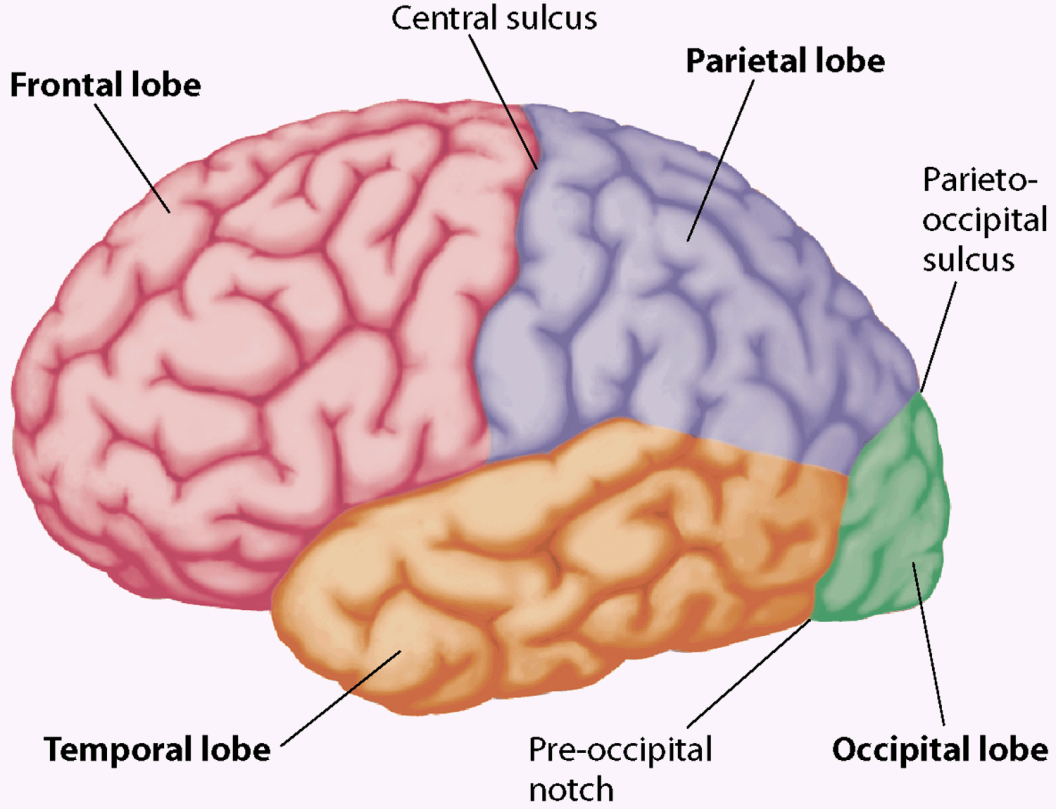
- Sagittal, coronal, and axial planes.

Functional neuroanatomy

- Broadman's area
  - Defined through histology
- Brain
  - Gray and white matter
  - Gyrus and sulcus
  - Lobes
  - Functional subdivision: e.g., within Frontal lobe
- Cortical maps: homunculus
  - Motor cortex and somatosensory cortex

Gross Anatomy: Lobes

Dorsal/ superior



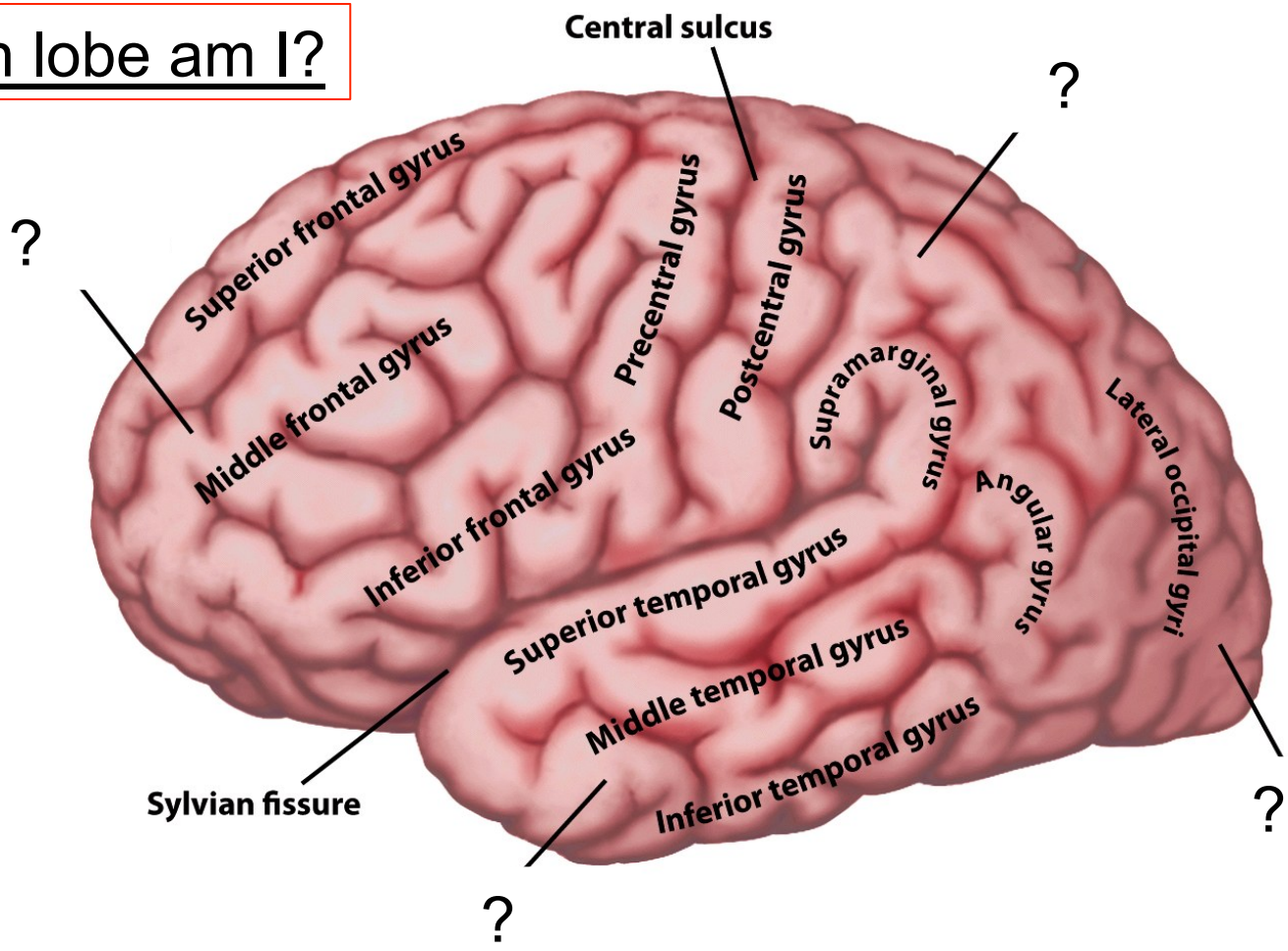
Anterior/ rostral

Posterior/ caudal

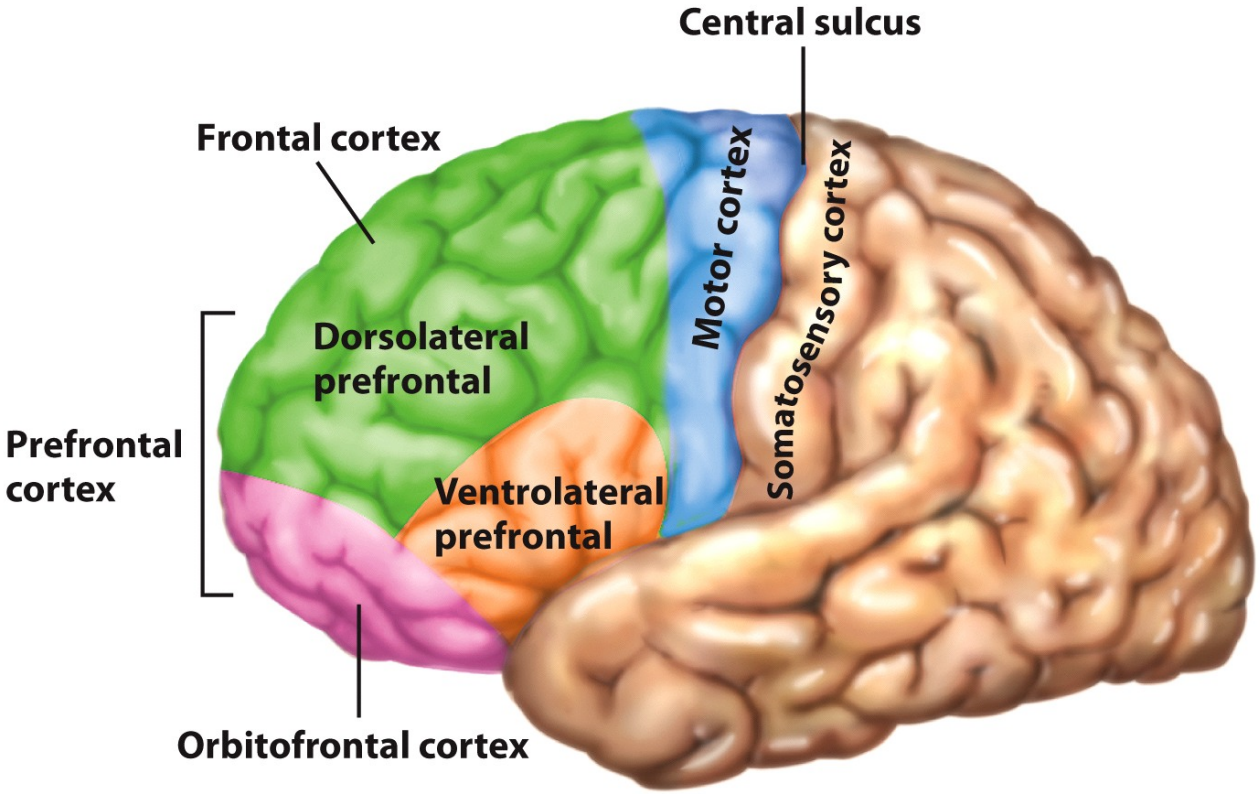
Ventral/ inferior

Gyri and Sulci on the lateral surface

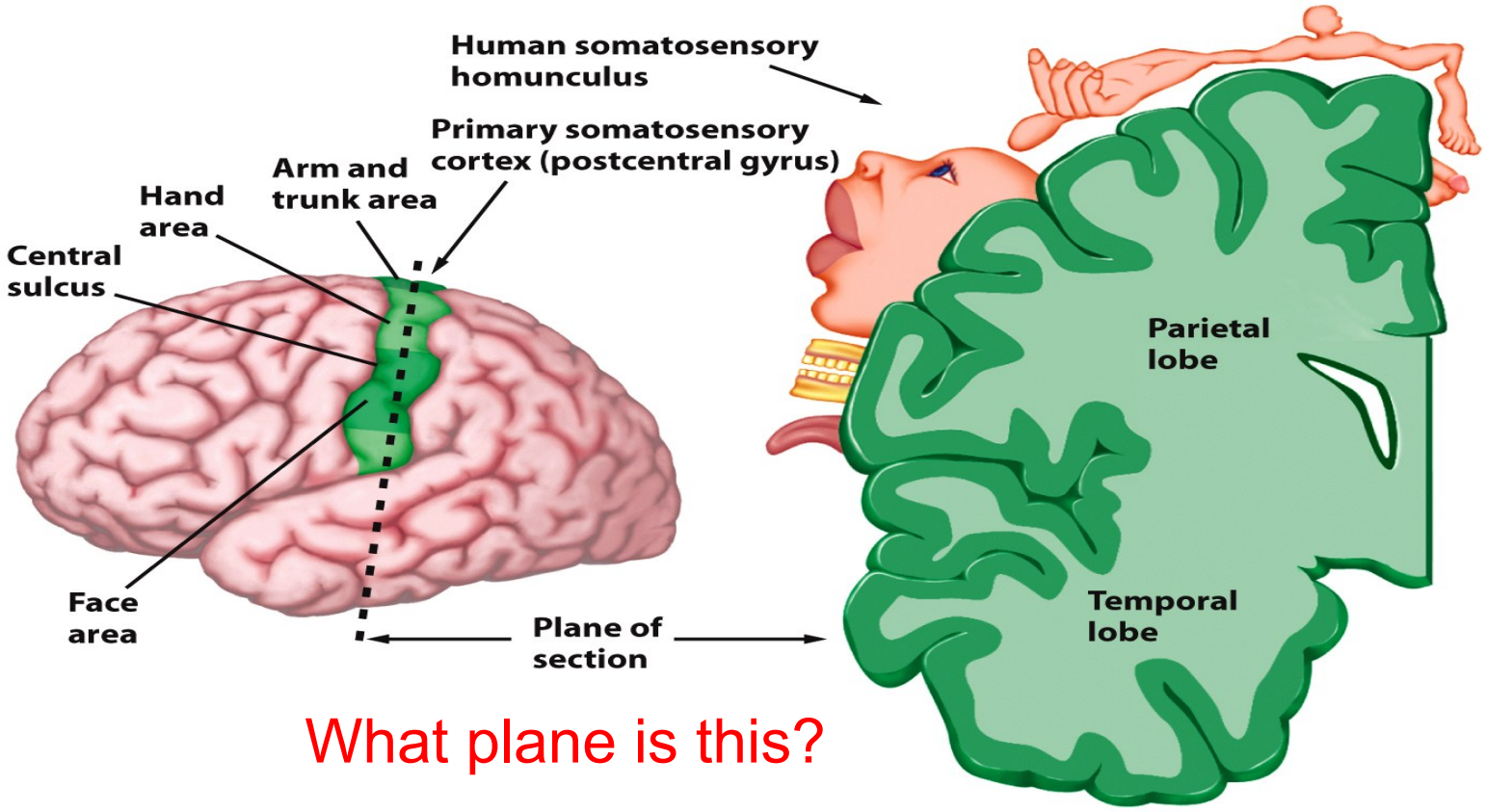
Which lobe am I?



Functional subdivisions of the brain



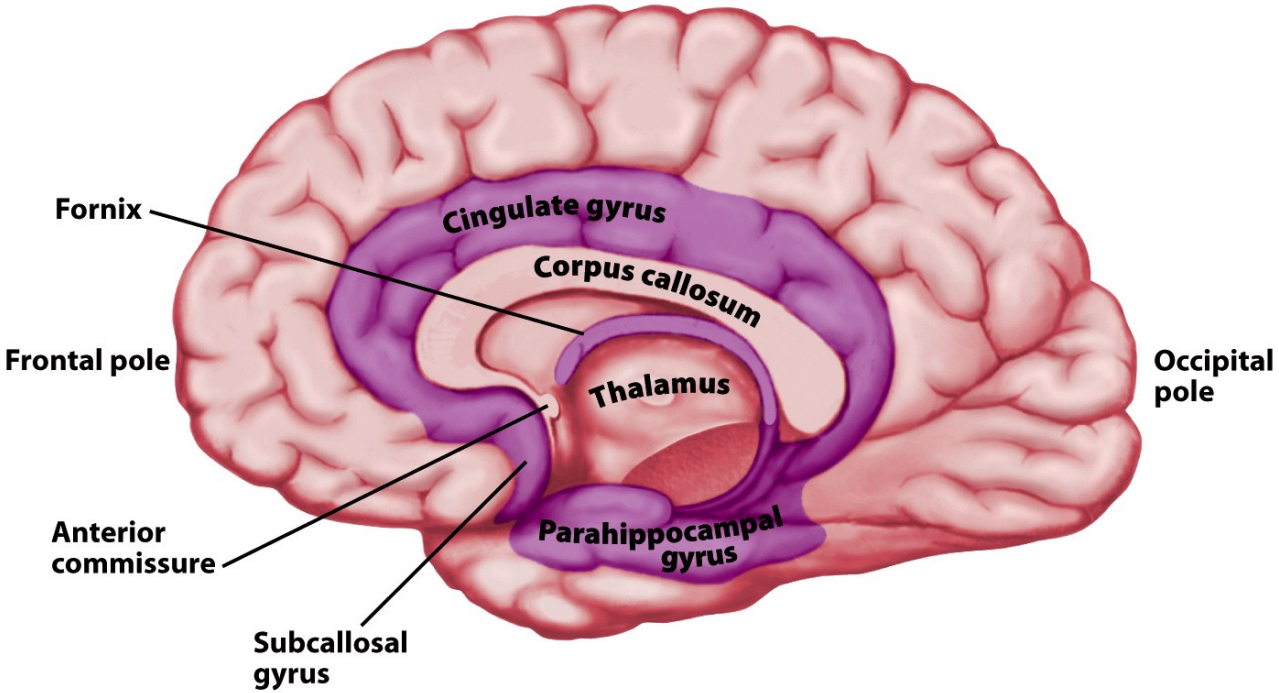
- Functional subdivisions based on loss of function from lesions or gain of function from stimulation.
- First discuss most basic functions these lobes perform.



What plane is this?

- Our representation of the somatosensory world is mapped onto our brains!
- Topographic correspondence between cortical regions & body surface

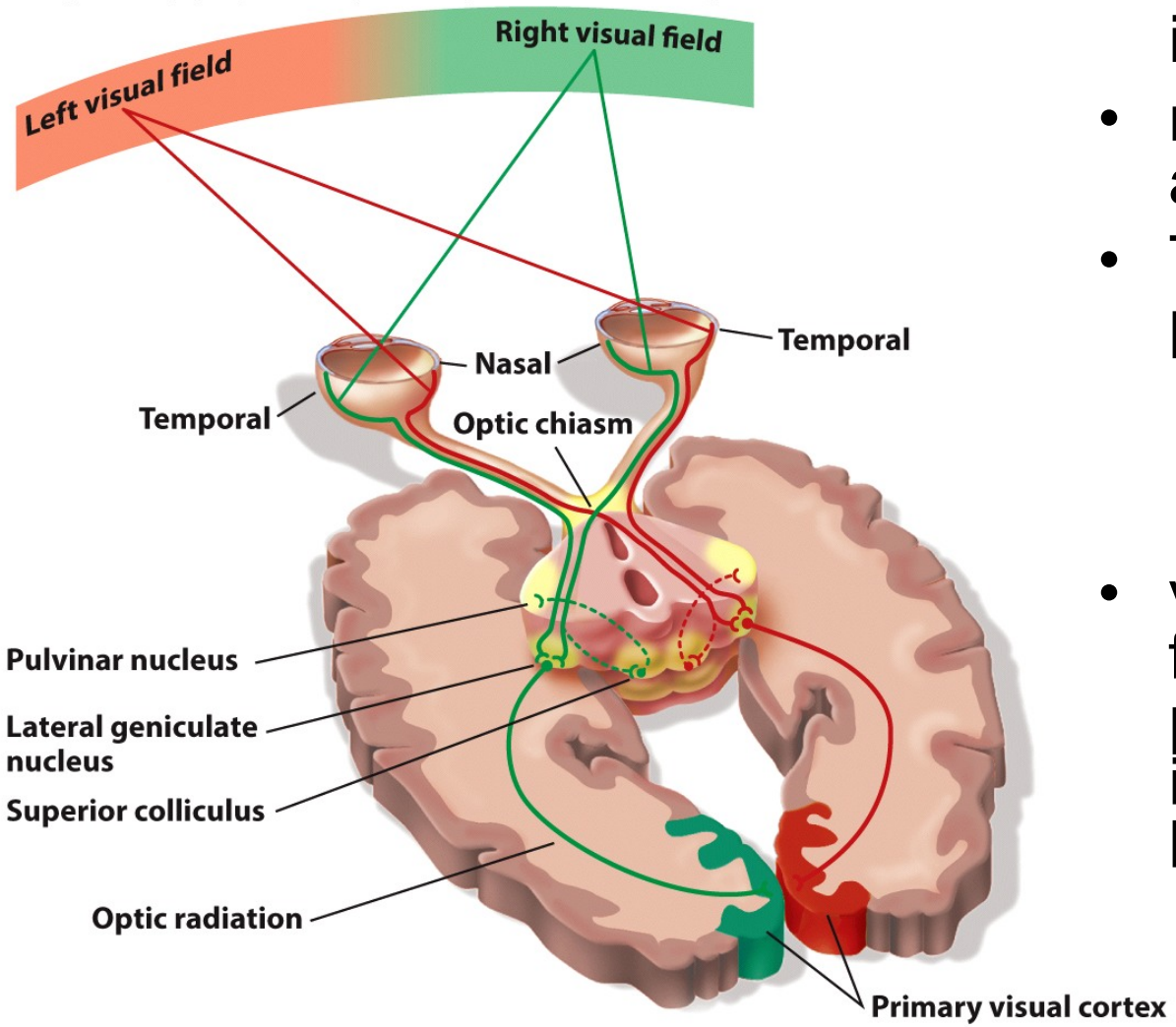
- Composed of hippocampus, hypothalamus, parts of thalamus, amygdala, and parts of basal ganglia.
- Limbic system: emotion and behavior, learning, memory



Essentials: Vision

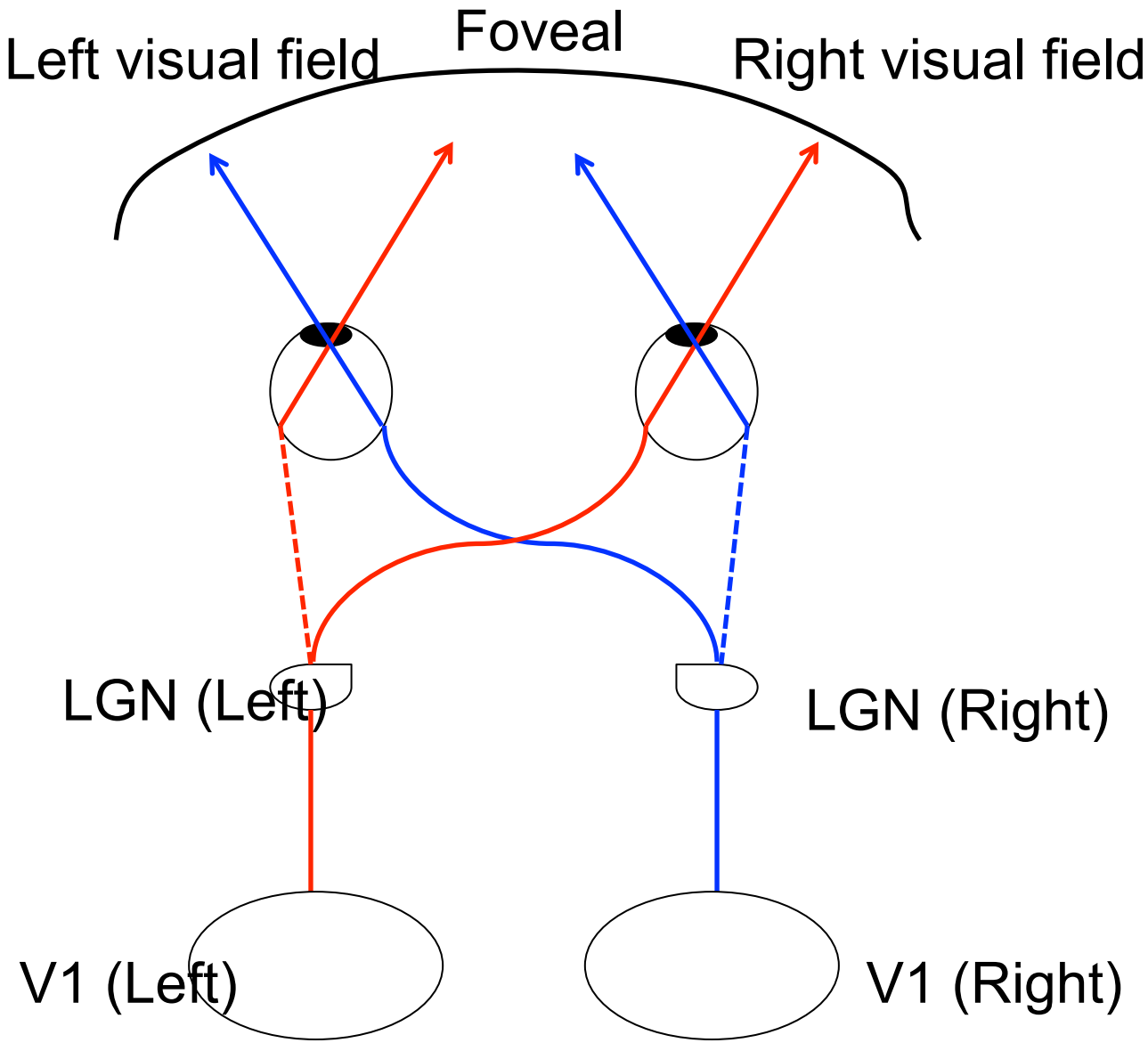
- Vision
  - Visual hierarchy & pathway
  - what happens with damages to different parts of visual pathway.
- Vision ≠ Camcorder: Flexible mapping between external world and perception
  - Functional overrepresentation
  - Cortical plasticity
  - Perceptual filling-in

Flow of information from optic nerve to V1

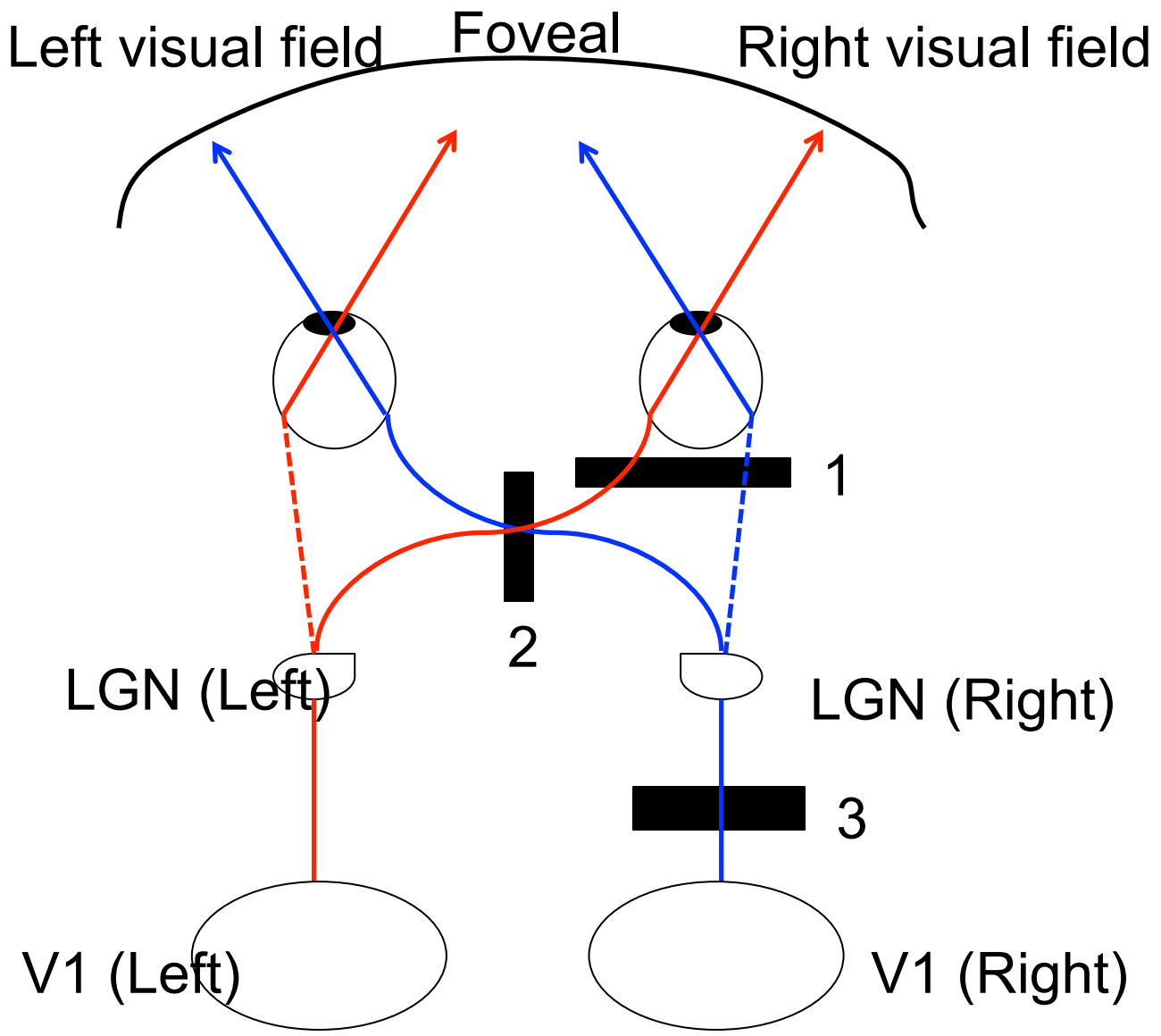


- temporal half of the retina project ipsilaterally
- nasal fibers cross over at the optic chiasm
- Two projection pathways
  - 90% to LGN in thalamus (cortical)
  - 10% subcortical
- visual input in each field is projected to the primary visual cortex in the contralateral hemisphere

Visual pathway

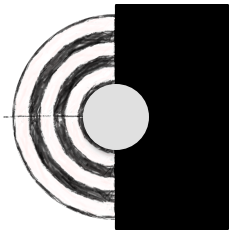


Visual pathway lesions



Visual field

1



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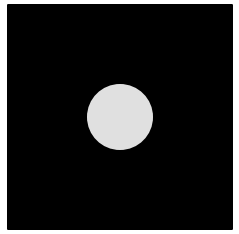

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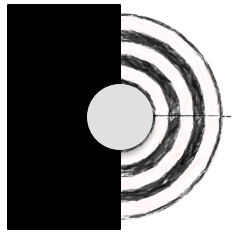
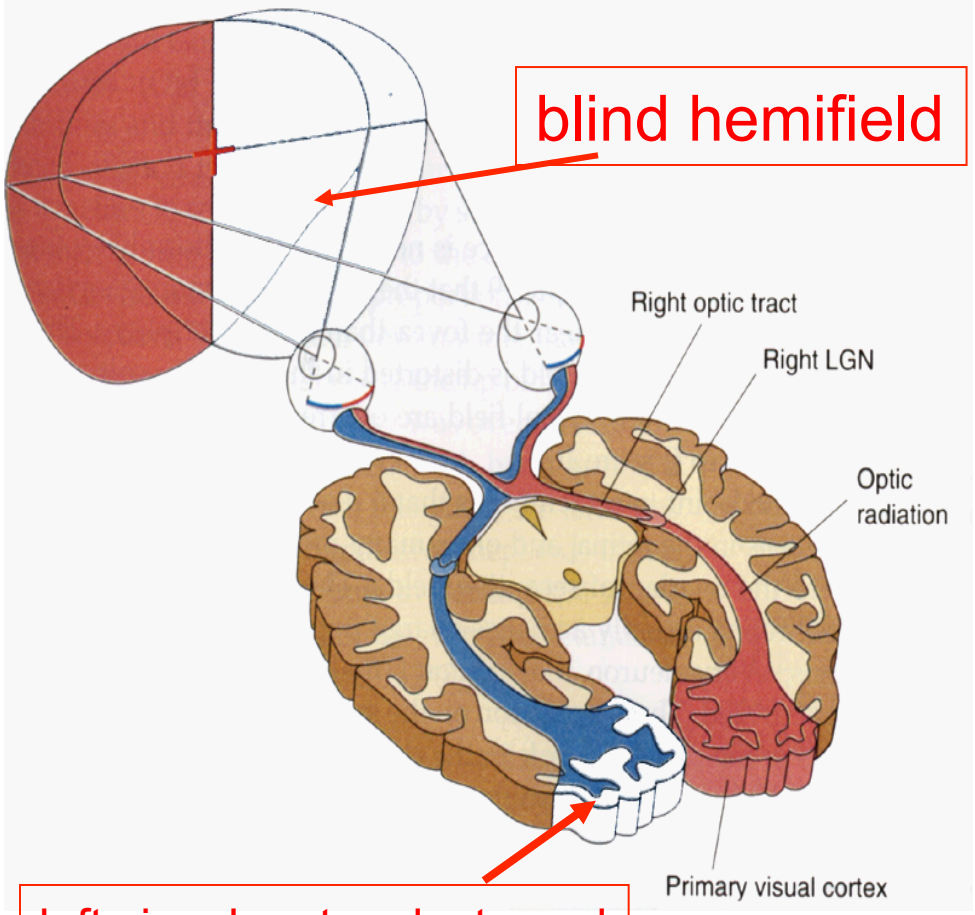


Blindsight: some perception in "blind" parts of visual field



Patient fixates cross and test for function in the blind hemi-field (make them guess)

In the blind field, patients can identify stimulus properties

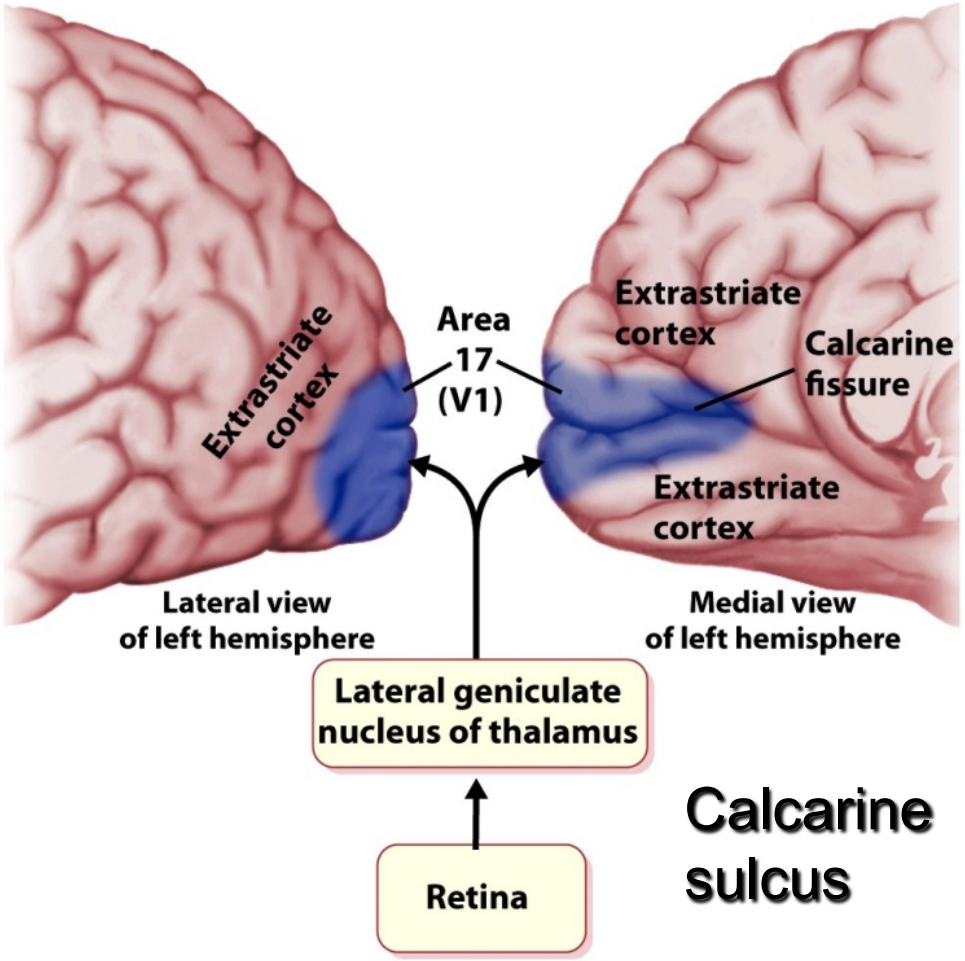
- direction of motion
- size
- line orientation
- simple shapes

How does this happen?

- Subcortical pathways
- residual V1 function

Weiskrantz

Next stop: Primary Visual Cortex, V1 (Brodmann area 17)



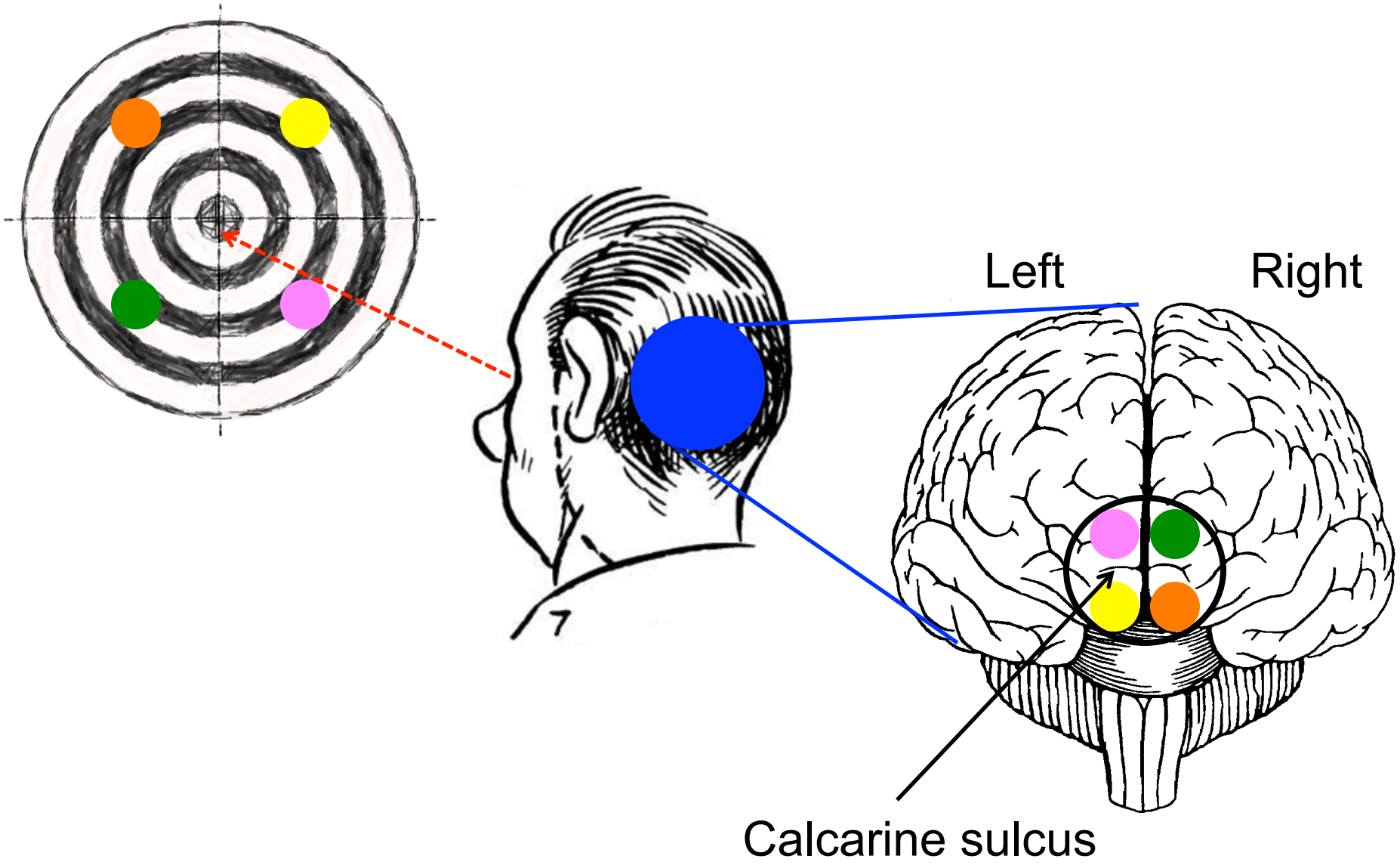
- Upper visual field = inferior to calcarine
- Lower visual field = superior to calcarine

e.g., visual world is flipped in cortex

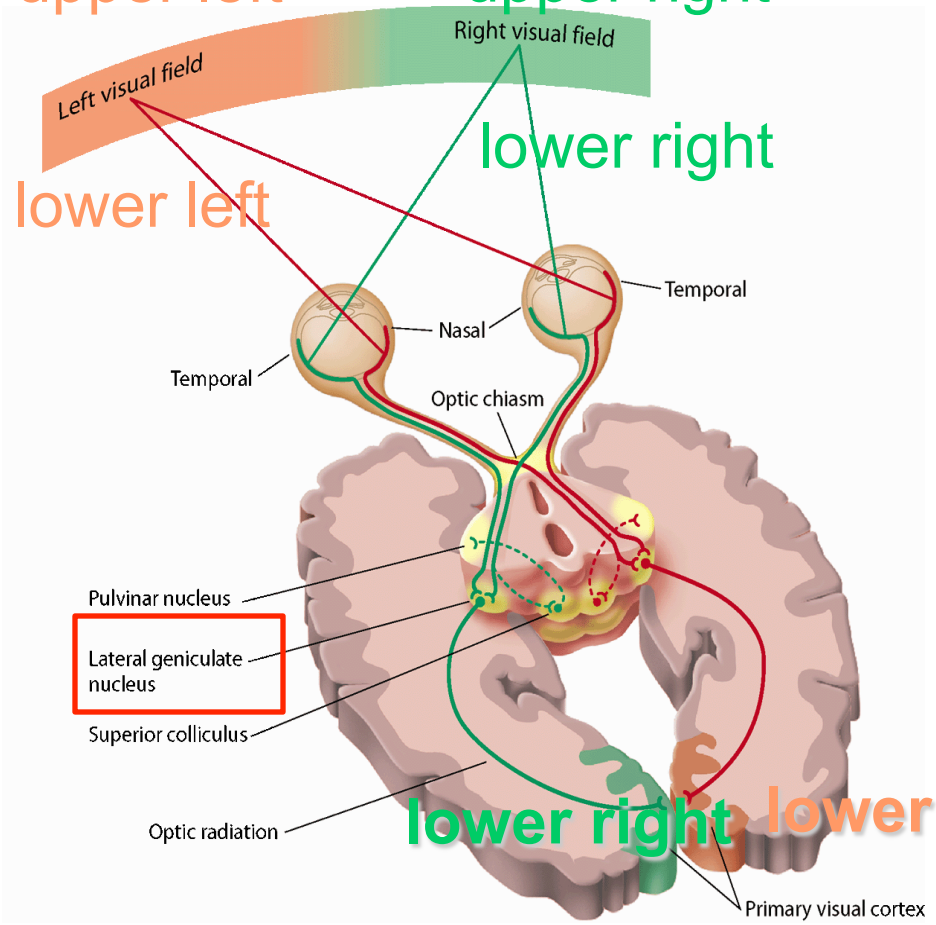
Calcarine sulcus divides upper + lower hemifields.

http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/what-where/what-where.html

Visual field and visual cortex

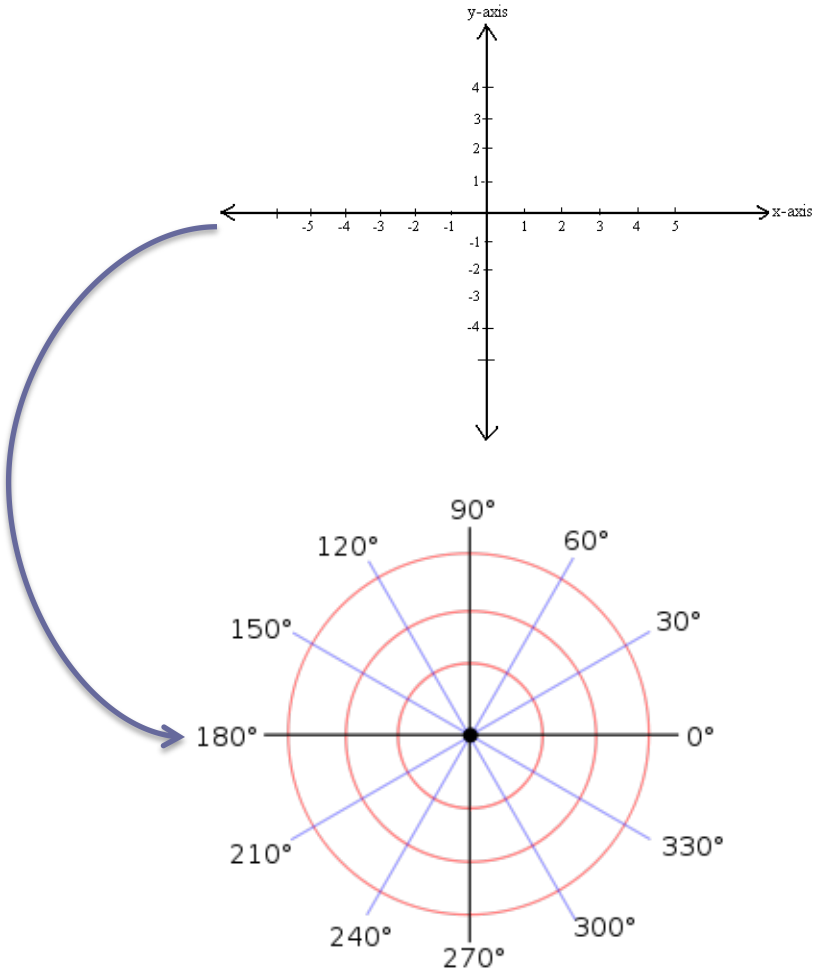


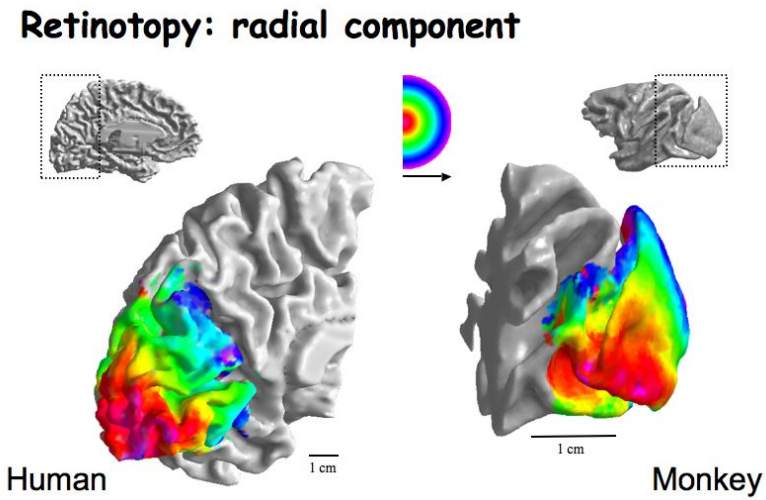
Inversion of visual world in cortex

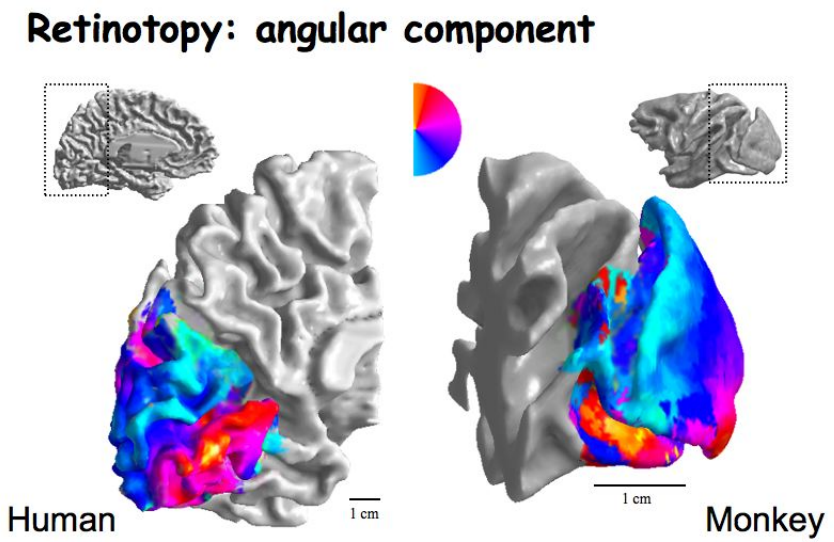


Transform Cartesian to Polar Coordinates

- topography of the visual world is preserved in V1~v4



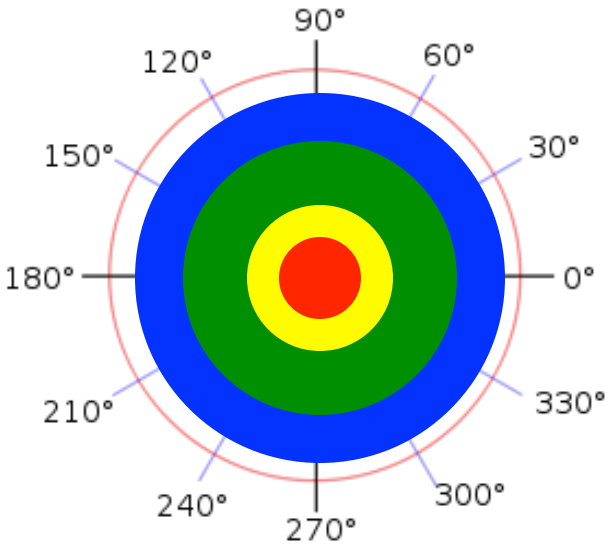


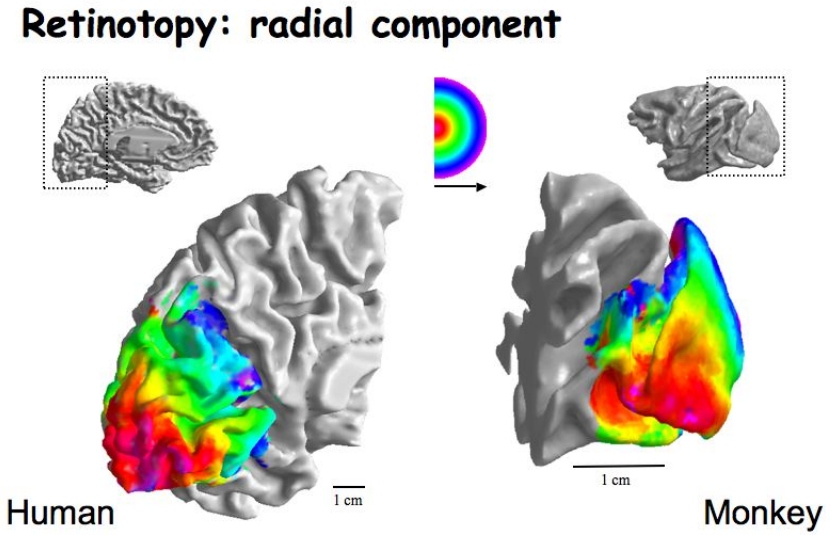


http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/what-where/what-where.html

Organization of visual cortex

- topography of the visual world is preserved in V1~v4





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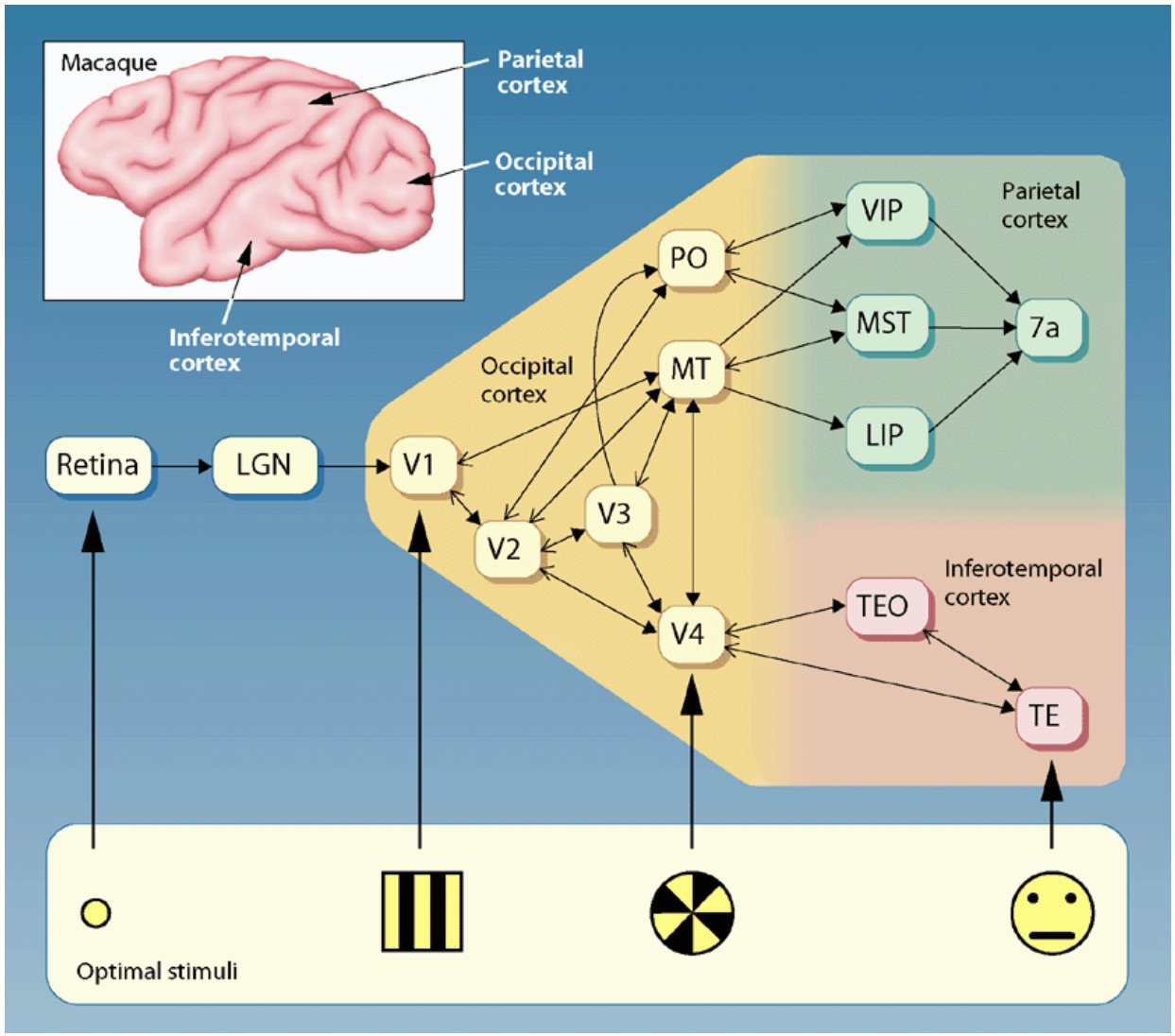
Next stop: V4, MT, LOC



Dorsal pathway

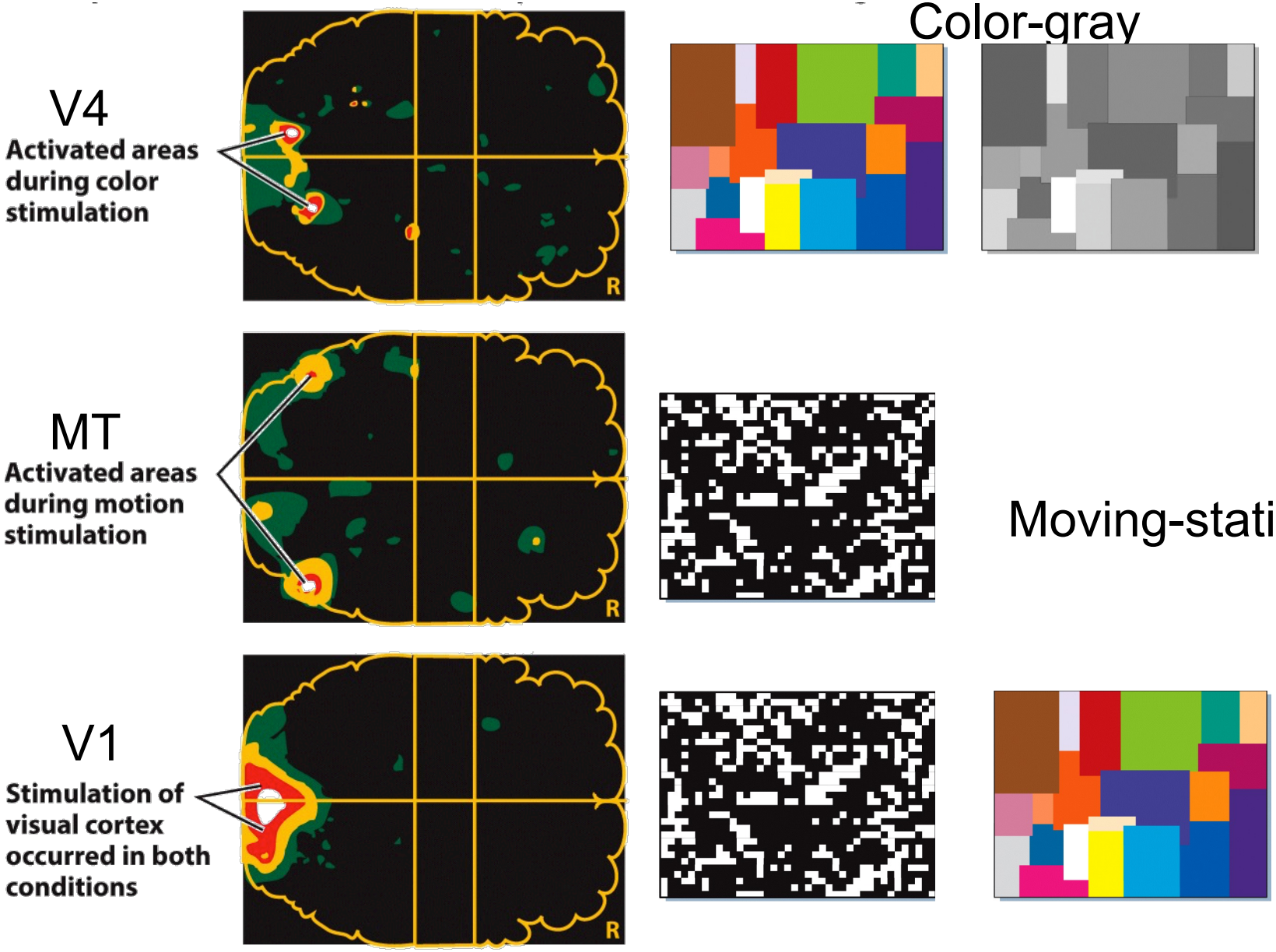
Ventral pathway

Van Essen and DeYoe 1995

“Modules” within the visual system

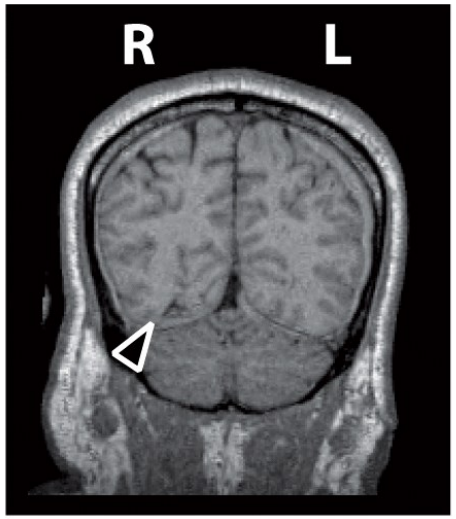
- Many areas in ventral pathway are thought to be selective for specific types of information (e.g., faces)
  - Recall debate between localizationism and holism
- Functional modularity (domain-specificity)?
  - Encapsulated information; impenetrable to cognitive influences; have “input criteria” (e.g., faces)
- Distributed processing (domain-generality)
  - rely on distributed or “emergent” properties of activity in multiple brain regions.

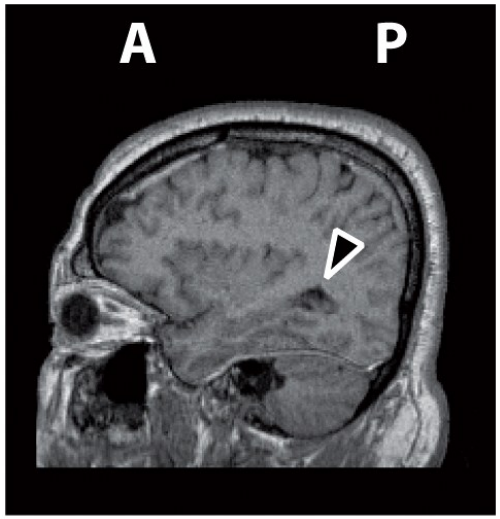
Specialized feature processing in the human brain

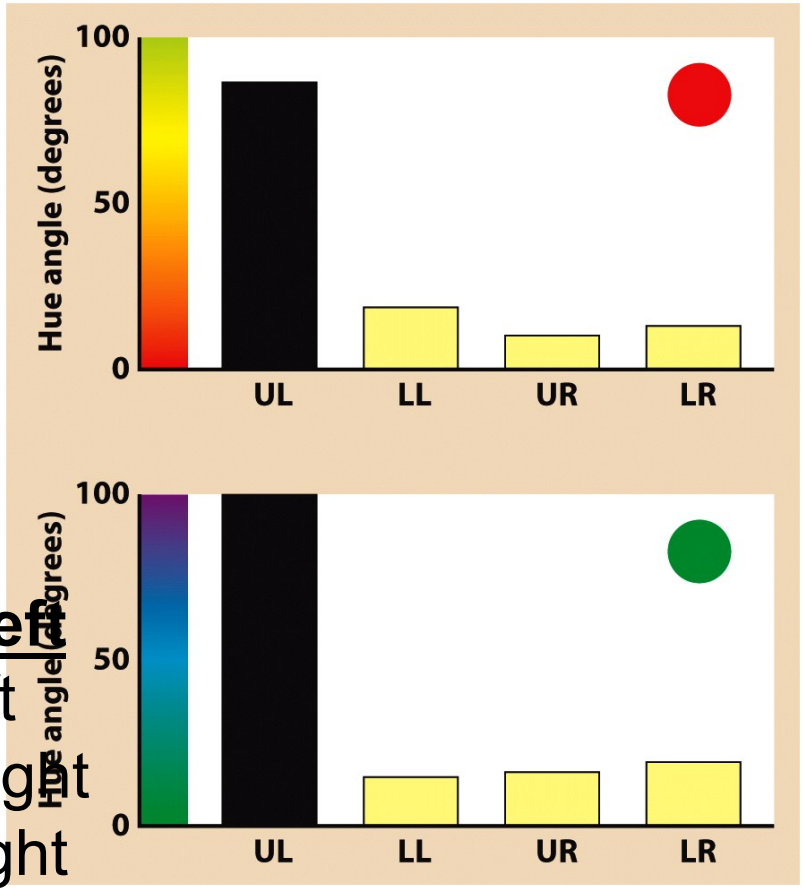


Zeki, S., 1993.

Color perception with a unilateral lesion of V4







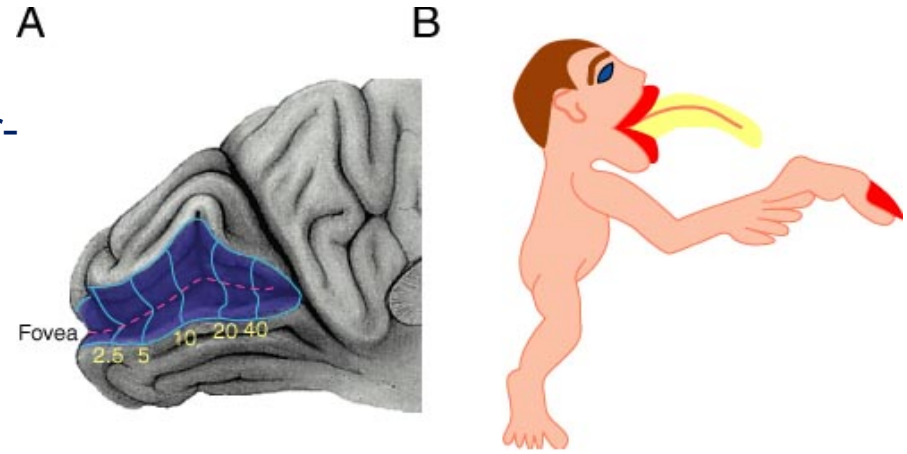
UL = upper left
LL = lower left
UR = upper right
LR = lower right

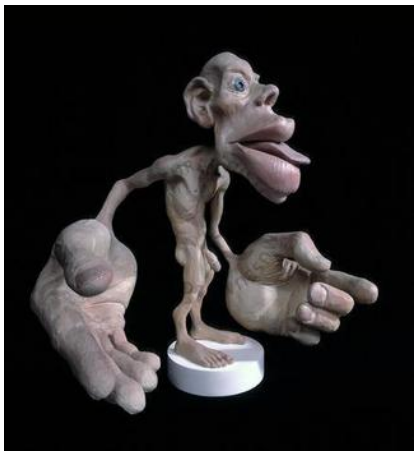
the color required to detect a difference between a patch each visual quadrant and the target color shown at the fovea

Perception is not a faithful replication of stimuli in the environment

- Perceptions are constructions by our CNS and reflect the behavioral function of sensory information.

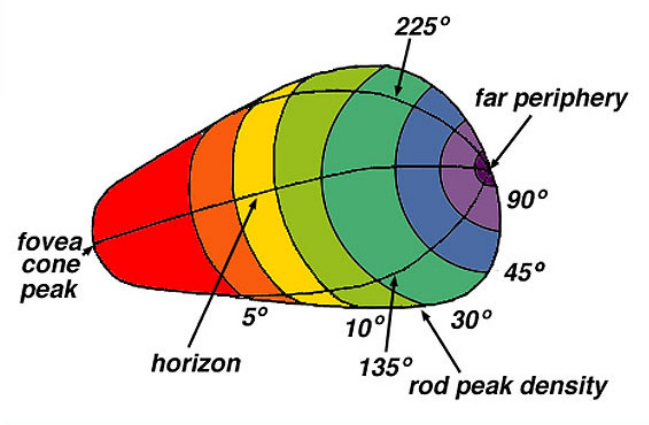
Visual system: over-representation of central vision.



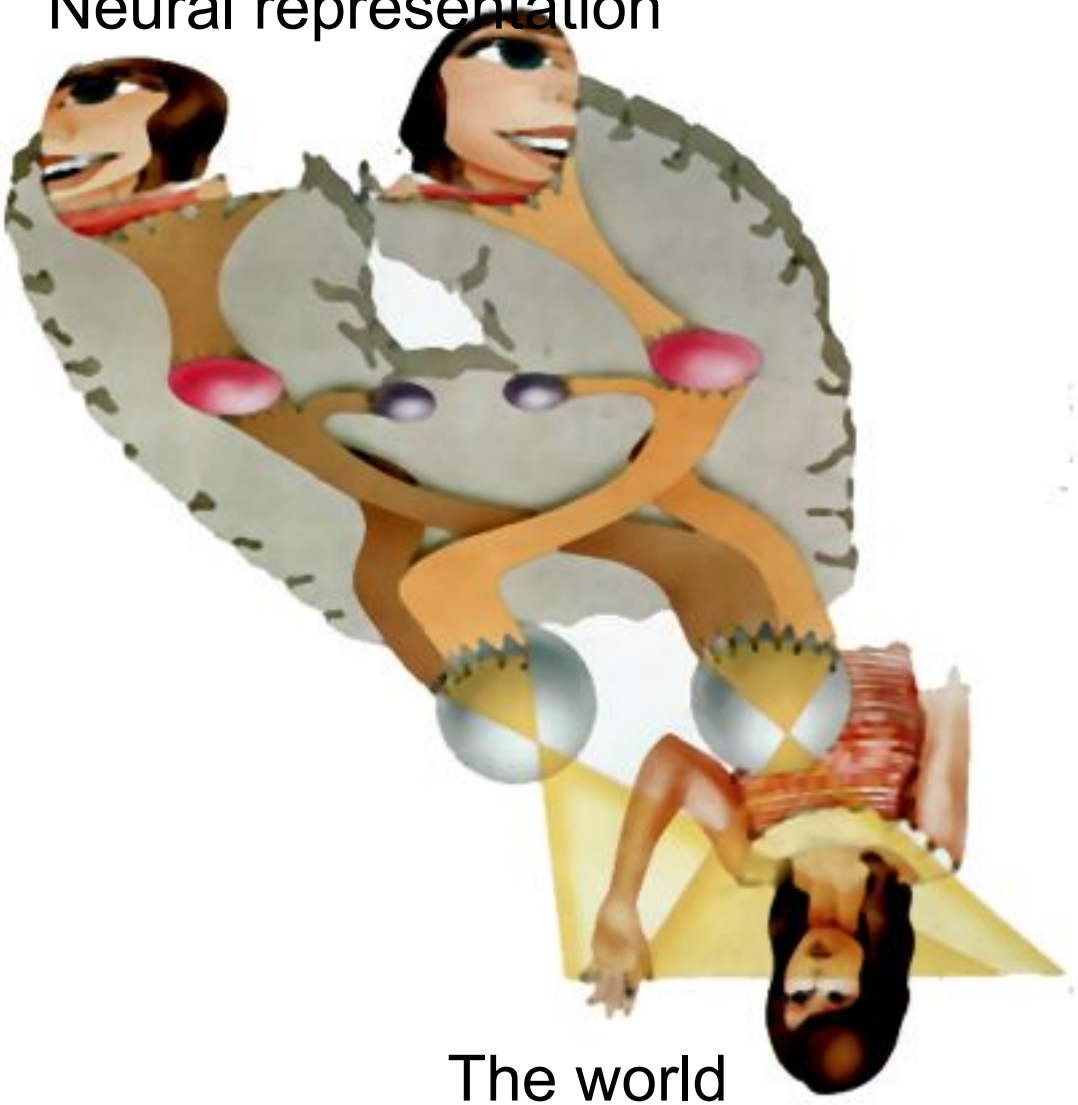


Somatosensory system: over-representation of thumb, mouth, tongue .

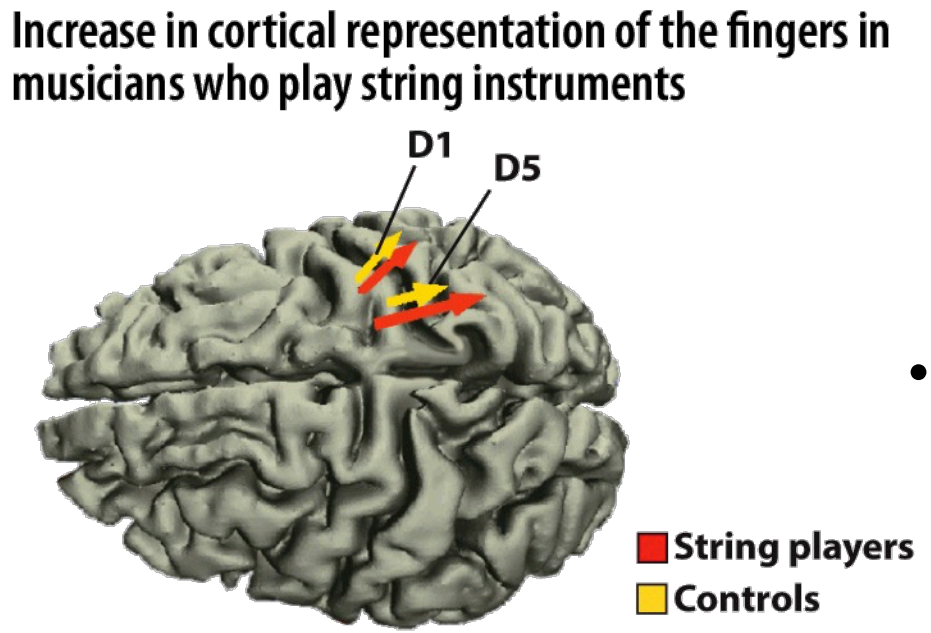
Cortical Magnification

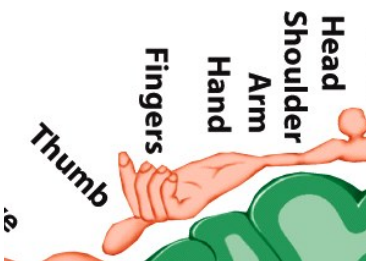


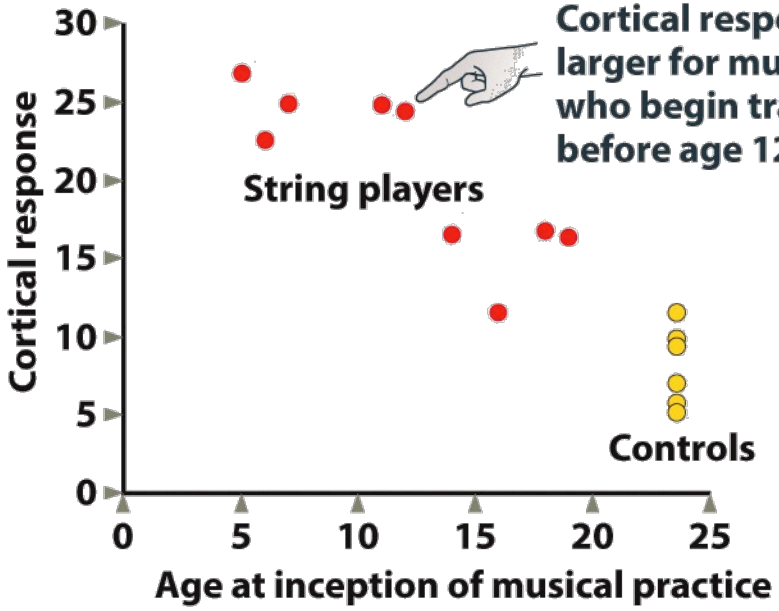
Neural representation



The world



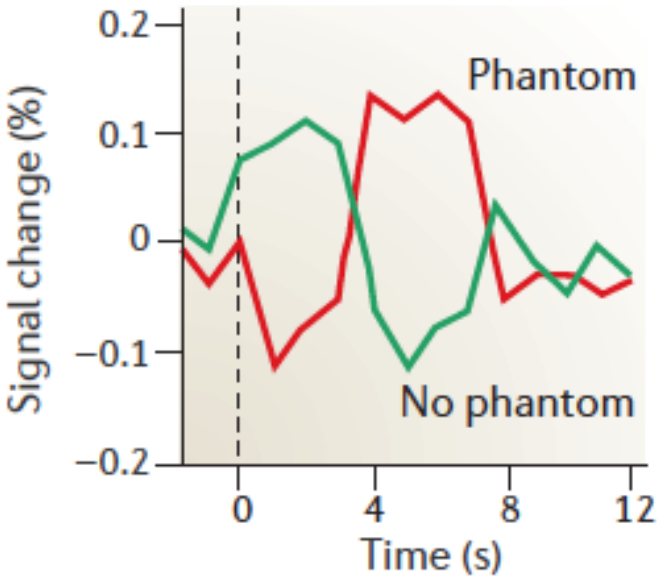


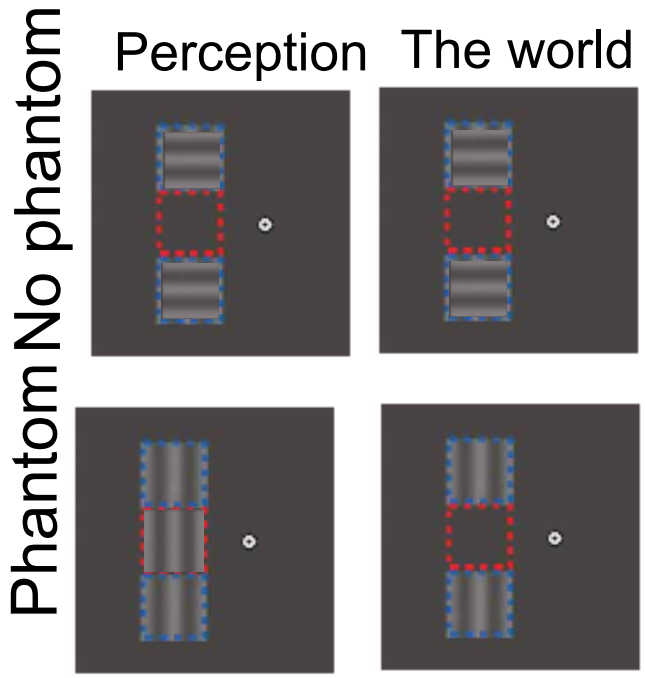


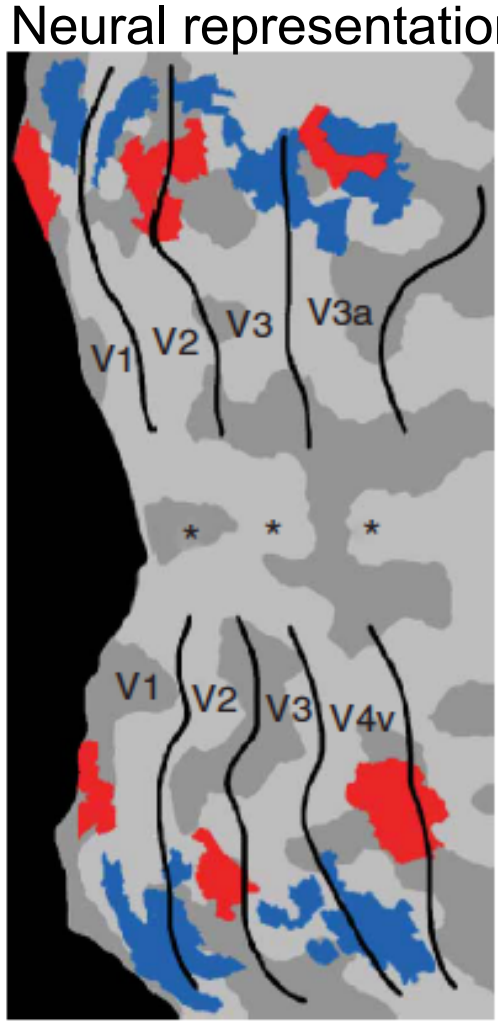
- Larger responses in somatosensory cortex following stimulation of thumb (D1) and pinkie (D5) for musicians than controls
- For musicians, the earlier musical training stated, the larger responses
- Enhanced thumb sensory representation for smartphone users
- Can be induced with just 10 days of touch screen use

Gindrat et al. (20

Perceptual Filling-in: Reconstructive

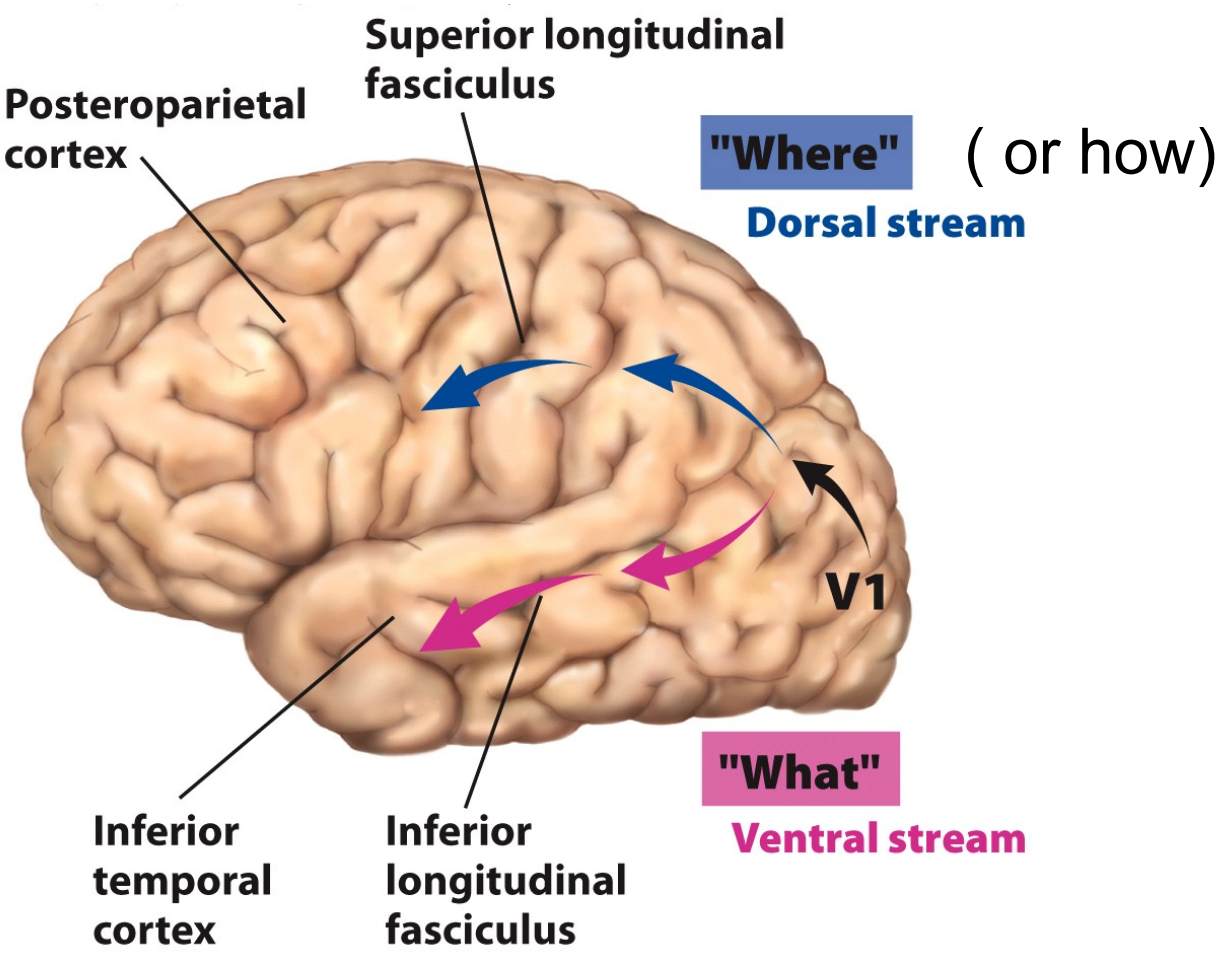




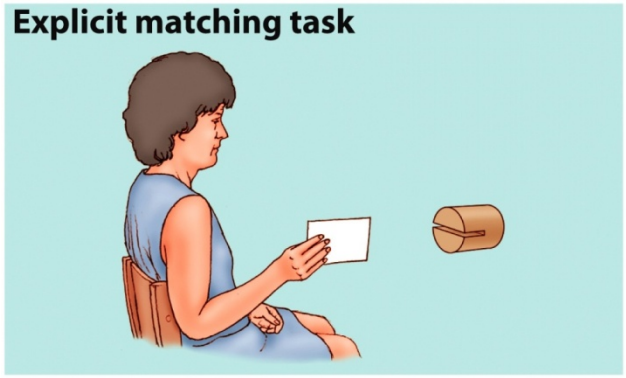


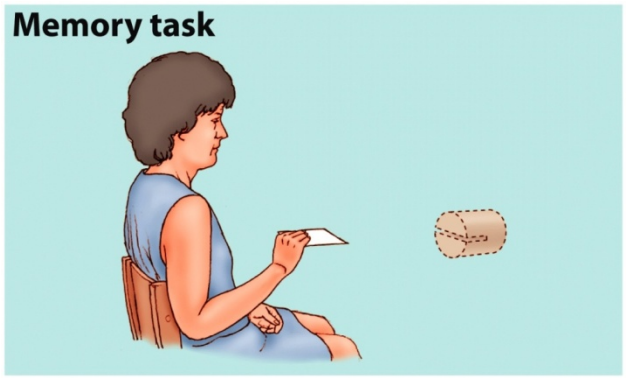
- The activity in the gap region (red square) increased after the phantom was perceived, and decreased when the phantom disappeared
- Providing the neural mechanisms of perceptual filling-in

Meng et al. (2005)


Superior longitudinal fasciculus
Posteroparietal cortex
"Where"
(or how)
Dorsal stream
V1
"What"
Ventral stream
Inferior temporal cortex
Inferior longitudinal fasciculus

Ventral “what” pathway lesion





- Bilateral LOC damage
- cannot recognize objects
  - can’t tell the orientation of the slot
- but knows *“how”* to act on them (or spatial location)
  - post a letter into it
  - also intact memory for action
  - Dorsal ‘where or how’

Sufficient versus necessary

- Necessary– if you damage it, that function goes away
  - Damage LOC, see object recognition damage
  - Same with Temporal lobe
- Sufficient – you only need one region for the function
  - Impossible to prove with neuropsych

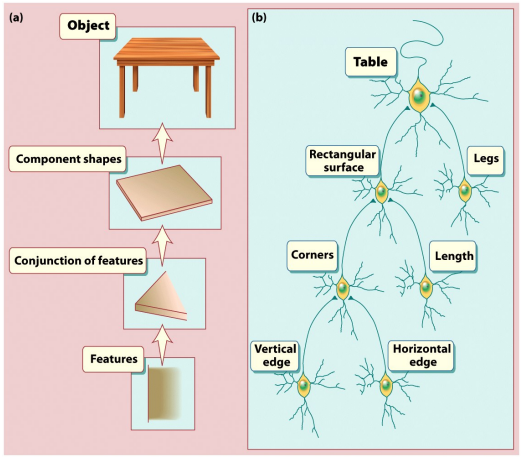
Grandmother versus Ensemble

Grandmother cell

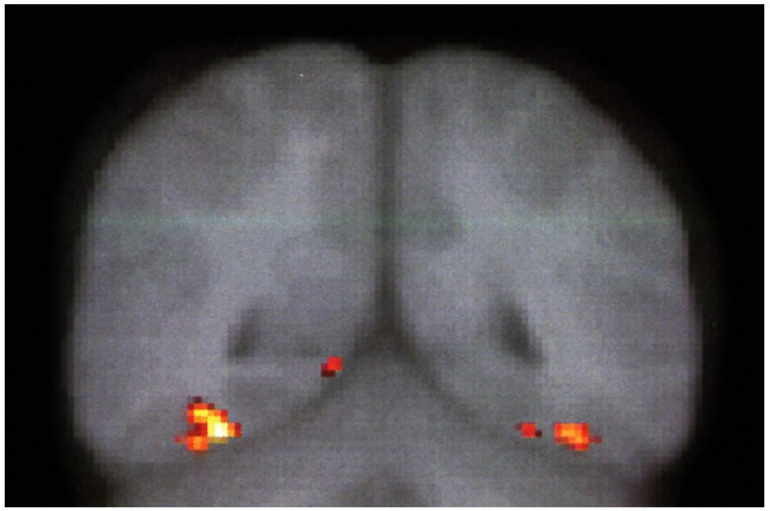
- One cell needed for every angle of your grandmother
- If lost, you can no longer perceive grandmother from that angle

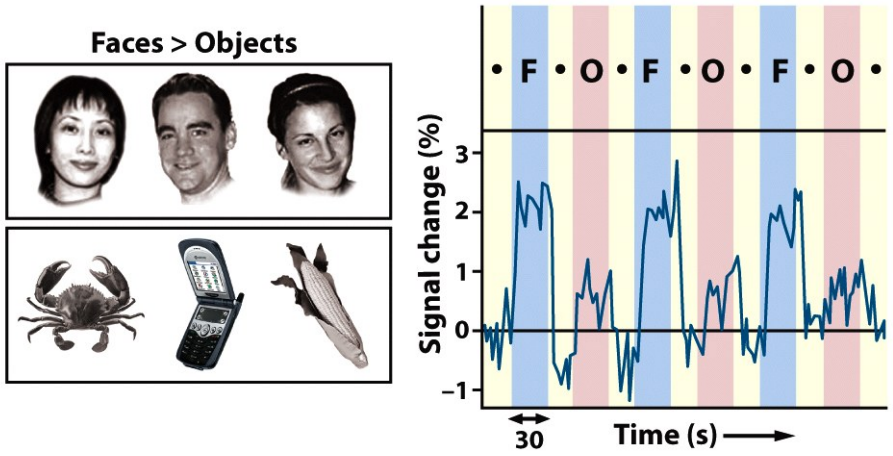
Ensemble

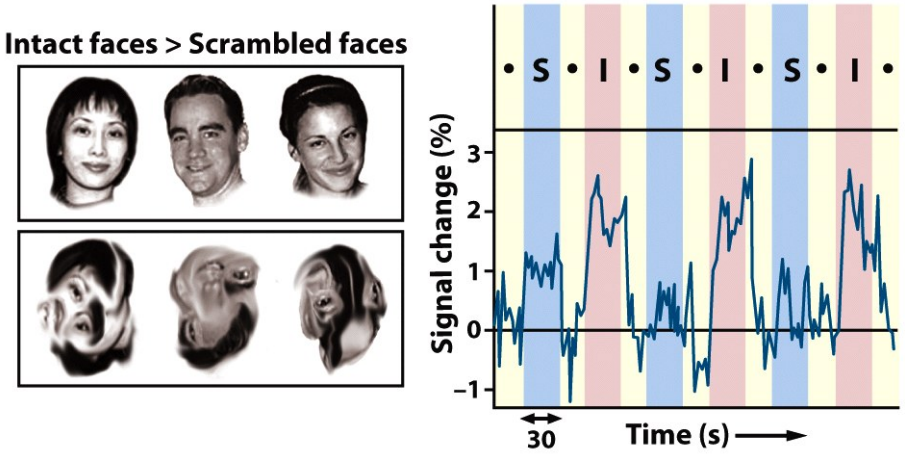
- Many neurons contribute to the cell (different attributes)
- If you loose one of them, you can still perceive your grandmother



Fusiform Gyrus

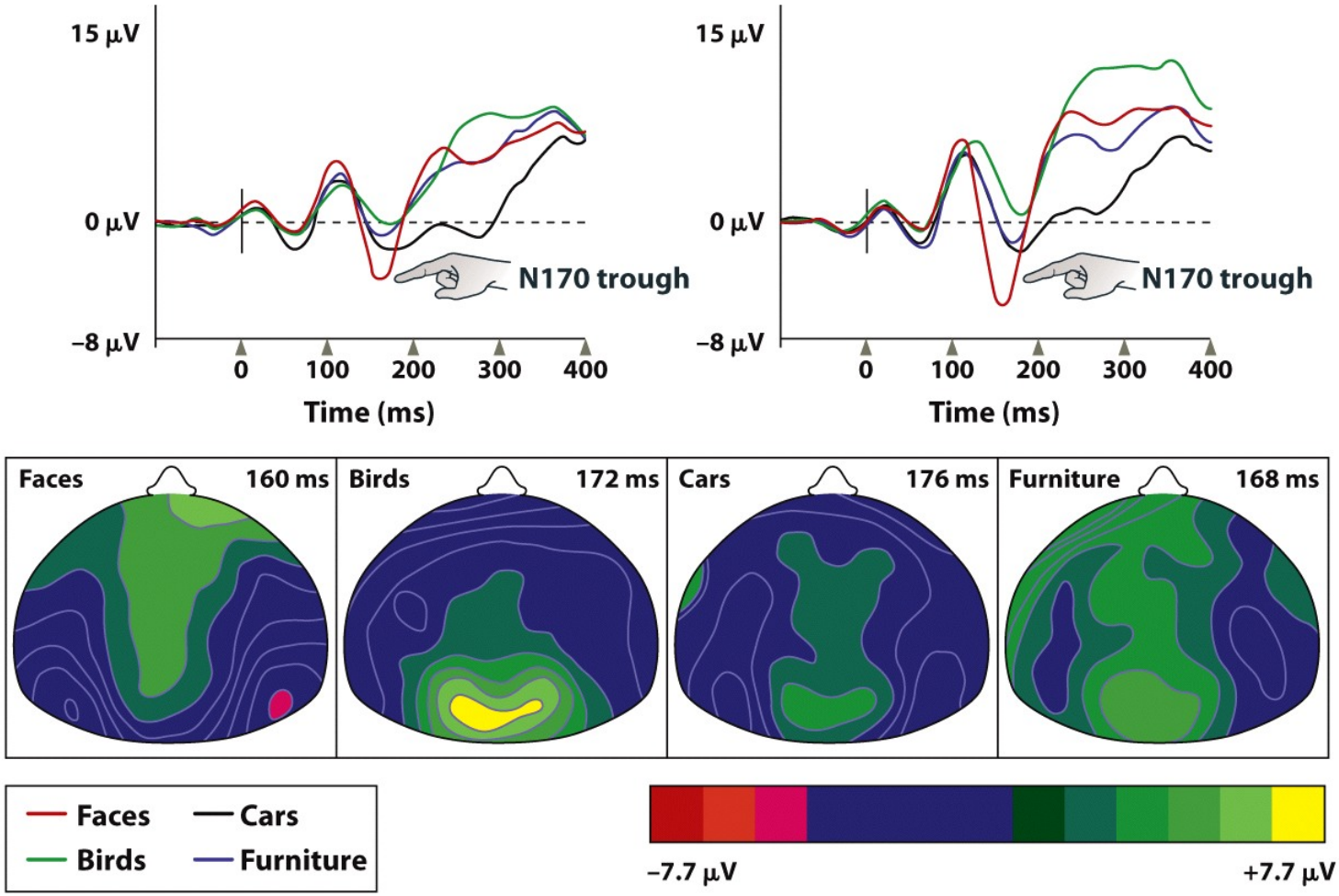




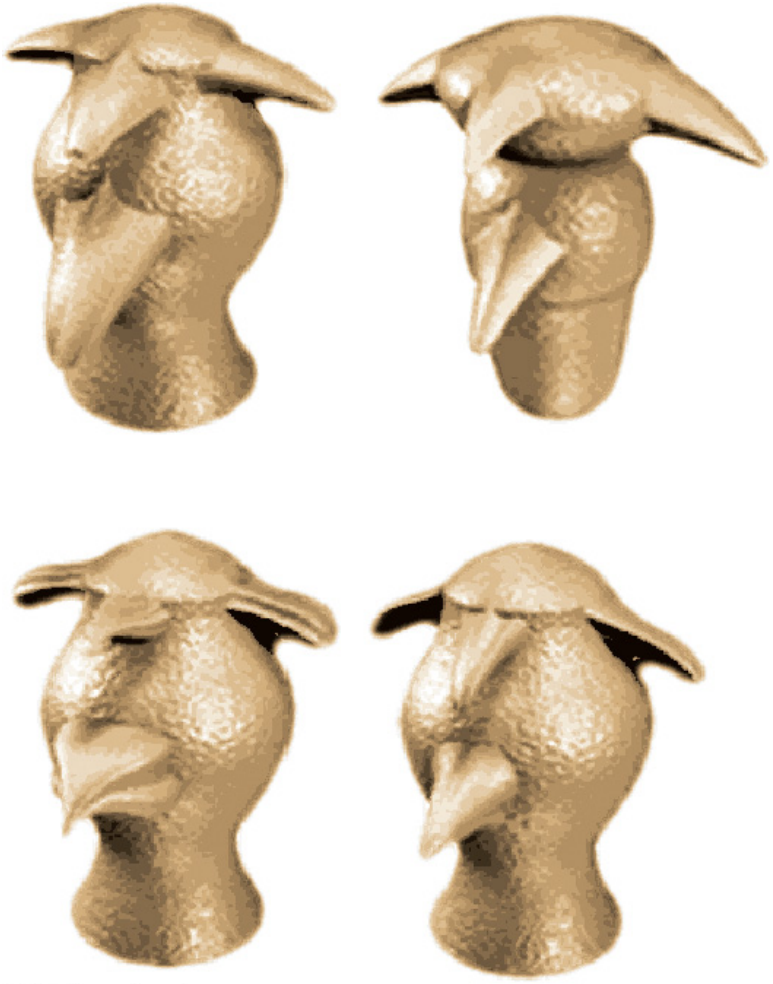


Why using scrambled face?

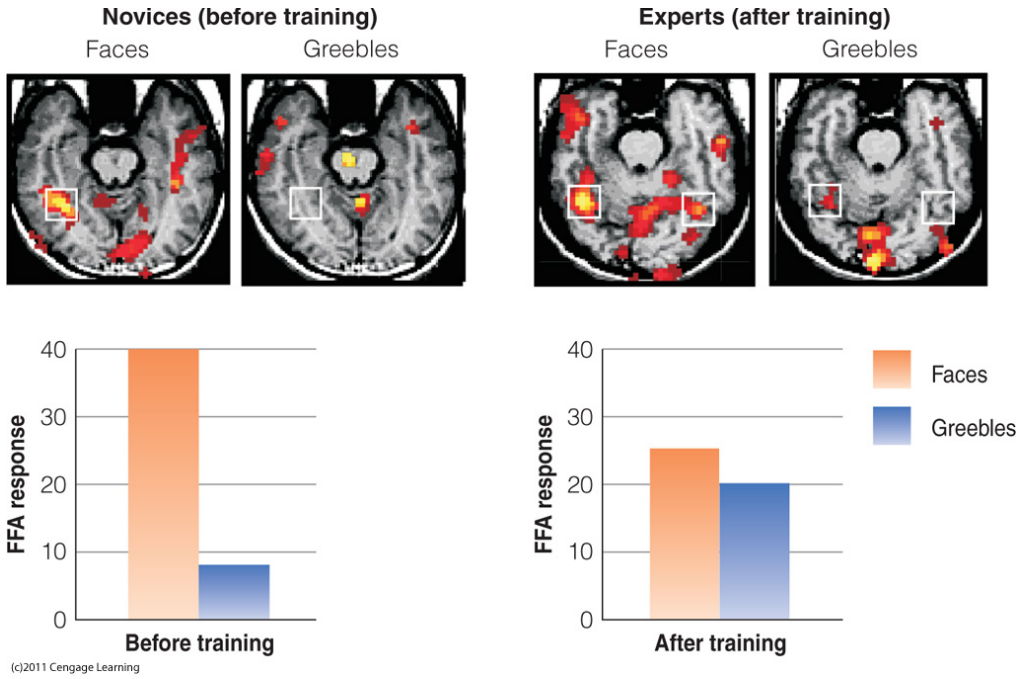
Face specific ERP (N170)



Expertise, yes!



Greeble stimuli used by Gauthier. Participants were trained to name each different Greeble.



Magnitude of brain responses to faces and Greebles (a) before and (b) after Greeble training. The colored areas in the brain records indicate brain activity. The FFA is located within the white squares.

Training modulates FFA activities